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DIVISION 03 - CONCRETE

SECTION 03101

FORMWORK FOR CONCRETE

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SECTION 03101

FORMWORK FOR CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 347R	(1994) Guide for Formwork for Concrete

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31/C 31M	(1998) Making and Curing Concrete Test Specimens in the Field
ASTM C 39/C 39M	(1999) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 1077	(1998) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

1.2 DESIGN REQUIREMENTS

The design, engineering, and construction of the formwork shall be the responsibility of the Contractor. The formwork shall be designed for anticipated live and dead loads and shall comply with the tolerances specified in Section 03305 CONCRETE, paragraph: CONSTRUCTION TOLERANCES. The formwork shall be designed as a complete system with consideration given to the effects of cementitious materials and mixture additives such as fly ash, cement type, plasticizers, accelerators, retarders, air entrainment, and others. The adequacy of formwork design and construction shall be monitored prior to and during concrete placement as part of the Contractor's approved Quality Control Plan.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawings

Drawings and design computations for all formwork required shall

be submitted at least 30 days either before fabrication on site or before delivery of prefabricated forms. If reshoring is permitted, the method, including location, order, and time of erection and removal shall also be submitted for review.

SD-03 Product Data

Materials

Manufacturer's literature shall be submitted for plywood, concrete form hard board, form accessories, prefabricated forms, form coating, and form-lining materials.

SD-04 Samples

Sample Panels; G

After shop drawings have been reviewed, sample panels for Class A finish with applied architectural treatment shall be built on the project site where directed.

SD-06 Test Reports

Inspection

The Contractor shall submit field inspection reports for concrete forms and embedded items.

1.4 SHOP DRAWINGS

The shop drawings and data submitted shall include the type, size, quantity, and strength of all materials of which the forms are made, the plan for jointing of facing panels, details affecting the appearance, and the assumed design values and loading conditions.

1.5 SAMPLE PANELS

Panels shall be of sufficient size to contain joints and shall be not less than 6 feet long and 4 feet wide. The panels shall be of typical wall thickness and constructed containing the full allocation of reinforcing steel that will be used in the structure, with the forming system that duplicates in every detail the one that will be used in construction of the structure. The same concrete mixture proportion and materials, the same placement techniques and equipment, and the same finishing techniques and timing shall be used that are planned for the structure. Construction of Class A finish will not be permitted until sample panels have been approved. Sample panels shall be protected from construction operations in a manner to protect approved finish, and are not to be removed until all Class A finish concrete has been accepted.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Forms and Form Liners

Forms and form liners shall be fabricated with facing materials that will produce a finish meeting the specified construction tolerance requirements and the following surface classifications as defined in ACI 347R.

2.1.1.1 Forms for High Velocity (HV) Finish

Due to rigid concrete tolerances required for the high velocity concrete the form shall be designed in accordance with ACI 347R for a 1/16 inch maximum deflection. Forms for this class of finish shall apply to surfaces specified in Section 03305, "Concrete," paragraph: High Velocity Finish. The form facing and structural material shall be composed of steel.

2.1.1.2 Forms for Permanent View (PV) Finish

Forms for this class of finish shall apply to surfaces specified in SECTION 03305: CONCRETE, paragraph: Permanent View Finish. The form facing material shall be composed of tongue-and-groove or shiplap lumber, plywood conforming to DOC PS-1, Grade B-B concrete form, tempered concrete form hard board or steel. Wood sheathing for curved or warped surfaces shall be composed of splines of lumber, which can be bent to the required shape without splitting or cracking, to form a smooth tight form.

2.1.1.3 Forms for Backfill (BF) Finish

Forms for this class of finish shall apply to all surfaces which will have backfill placed against the concrete surface. The sheathing shall be composed of plywood conforming to DOC PS-1. Grade B-B concrete form, tempered concrete form hardboard, or steel. Steel lining on wood sheathing will not be permitted.

2.1.2 Form Coating

Form coating shall be commercial formulation that will not bond with, stain, cause deterioration, or any other damage to concrete surfaces. The coating shall not impair subsequent treatment of concrete surfaces depending upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds. If special form liners are to be used, the Contractor shall follow the recommendation of the form coating manufacturer.

2.2 ACCESSORIES

Ties and other similar form accessories to be partially or wholly embedded in the concrete shall be of a commercially manufactured type. After the ends or end fasteners have been removed, the embedded portion of metal ties shall terminate not less than 2 inches from any concrete surface either exposed to view or exposed to water. Plastic snap ties shall not be used. Form ties shall be constructed so that the ends or end fasteners can be removed without spalling the concrete.

2.3 WATER STOPS

Forms shall have a mechanical device to secure the waterstop to the form bulkhead. Waterstops will not be secured through the use of any device which requires the perforation of the waterstop to hold it in place.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Form Construction

Forms shall be constructed true to the structural design and required alignment. The form surface and joints shall be mortar tight and supported to achieve safe performance during construction, concrete placement, and form removal. The Contractor shall continuously monitor the alignment and stability of the forms during all phases to assure the finished product will meet the required surface classes specified in paragraph: FORMS AND FORM LINERS and tolerances specified in paragraph: DESIGN REQUIREMENTS. Failure of any supporting surface either due to surface texture, deflection or form collapse shall be the responsibility of the Contractor as will the replacement or correction of unsatisfactory surfaces. When forms for continuous surfaces are placed in successive units, care shall be taken to fit the forms over the completed surface to obtain accurate alignment of the surface and to prevent leakage of mortar and edge spalling. Concrete edges shall be protected with wood until matching concrete is placed. Forms shall not be re-used if there is any evidence of defects which would impair the quality of the resulting concrete surface. All surfaces of used forms shall be cleaned of mortar and any other foreign material before reuse.

3.1.2 Chamfering

All exposed joints, edges and external corners shall be chamfered by molding placed in the forms unless the drawings specifically state that chamfering is to be omitted or as otherwise specified. Joints between cement, for all gate chamfer, downstream conduit, stilling basin, and the silt channel, shall not have chamfers on the inside (flow surfaces). Chamfered joints shall not be permitted where earth or rockfill is placed in contact with concrete surfaces. Chamfered joints shall be terminated twelve inches outside the limit of the earth or rockfill so that the end of the chamfers will be clearly visible.

3.1.3 Coating

Forms for exposed or painted surfaces shall be coated with form oil or a form-release agent before the form or reinforcement is placed in final position. The coating shall be used as recommended in the manufacturer's instructions. Surplus coating on form surfaces and coating on reinforcing steel and construction joints shall be removed before placing concrete.

3.2 FORM REMOVAL

Forms shall not be removed without approval. The minimal time required for concrete to reach a strength adequate for removal of formwork without risking the safety of workers or the quality of the concrete depends on a number of factors including, but not limited to, ambient temperature, concrete lift heights, type and amount of concrete admixture, and type and amount of cementitious material in the concrete. It is the responsibility of the Contractor to consider all applicable factors and leave the forms in place until it is safe to remove them. In any case forms shall not be removed unless the minimum time and minimum compressive strength requirements below are met, except as otherwise directed or specifically authorized. When conditions are such as to justify the requirement, forms will be required to remain in place for a longer period. All removal shall be accomplished in a manner which will prevent damage to the concrete and ensure the complete safety of the structure. Where forms support more than one element, the forms shall not be removed until the form removal criteria are met by all supported elements. Form removal shall be scheduled so that all necessary repairs can be performed as specified in Section 03305, CONCRETE. Evidence that concrete has gained sufficient strength to permit

removal of forms shall be determined by tests on control cylinders. All control cylinders shall be stored in the structure or as near the structure as possible so they receive the same curing conditions and protection methods as given those portions of the structure they represent. Control cylinders shall be removed from the molds at an age of no more than 24 hours. All control cylinders shall be prepared and tested in accordance with ASTM C 31/C 31M and ASTM C 39/C 39M at the expense of the Contractor by an independent laboratory that complies with ASTM C 1077 and shall be tested within 4 hours after removal from the site.

3.2.1 Formwork Not Supporting Weight of Concrete

Formwork for walls, columns, sides of beams, gravity structures, and other vertical type formwork not supporting the weight of concrete shall not be removed in less than 24 hours after concrete placement is completed. The time depends on temperature, lift heights, and type and amount of cementitious material in the concrete. Where forms for columns, walls, and sides of beams also support formwork for slabs or beam soffits, the removal time of the latter shall govern.

3.2.2 Formwork Supporting Weight of Concrete

Formwork supporting weight of concrete and shoring shall not be removed until structural members have acquired sufficient strength to safely support their own weight and any construction or other superimposed loads to which the supported concrete may be subjected. As a minimum, forms shall be left in place until control concrete test cylinders indicate evidence the concrete has attained at least 70 percent of the compressive strength required for the structure in accordance with the quality and location requirements of Section 03305.

3.3 INSPECTION

Forms and embedded items shall be inspected in sufficient time prior to each concrete placement by the Contractor in order to certify to the Contracting Officer that they are ready to receive concrete. The results of each inspection shall be reported in writing.

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DIVISION 03 - CONCRETE

SECTION 03150

EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS

-- End of Section Table of Contents --

SECTION 03150

EXPANSION JOINTS, CONTRACTION JOINTS, AND WATERSTOPS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 920	(1998) Elastomeric Joint Sealants
ASTM D 1751	(1983; R 1991) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(1984; R 1996) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 2628	(1991) Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements

CORPS OF ENGINEERS (COE)

COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops

CALIFORNIA STATE DEPARTMENT OF TRANSPORTATION (CALTRANS)

California Test 435	Two-Component Machine Mixed Polyurethan Sealants
California Test 673	Movement Rating of Type B1 and Type B2 Preformed Elastomeric Joint Seals

CORPS OF ENGINEERS (COE)

COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstops

FEDERAL SPECIFICATIONS (FS)

FS LLL-B-810	(1973) Building Board, (Hardboard) Hard Pressed, Vegetable Fiber

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Preformed Expansion Joint Filler, G
Sealants, G
Compression Seals, G
Tempered Hardboard, G
Expanded Polystyrene, G
Waterstops; G

Manufacturer's literature, including safety data sheets, for preformed fillers and the lubricants used in their installation; field-molded sealants and primers (when required by sealant manufacturer); preformed compression seals; and waterstops, including procedures for splicing waterstops.

Preformed Expansion Joint Filler
Compression Seals and Lubricants
Waterstops

Manufacturer's recommended instructions for installing preformed fillers, field-molded sealants; preformed compression seals; and waterstops; and for splicing non-metallic waterstops.

SD-04 Samples

Compression Seals and Lubricants; G

Specimens identified to indicate the manufacturer, type of material, size and quantity of material, and shipment or lot represented. Each sample shall be a piece not less than 9 ft of 1 inch nominal width or wider seal or a piece not less than 12 ft of compression seal less than 1 inch nominal width. One quart of lubricant shall be provided.

Field-Molded Sealants and Primer; G

One gallon of field-molded sealant and one quart of primer (when primer is recommended by the sealant manufacturer) for testing.

Waterstops; G

Waterstop material and splice samples shall be submitted for inspection and testing and shall be identified to indicate manufacturer, type of material, size, quantity of material, and shipment represented. Each material sample shall be a piece not less than 12 inch long cut from each 200 ft of finished waterstop furnished, but not less than a total of 4 linear feet of each type, and size furnished. For spliced segments of waterstops to be installed in the work, one splice sample of each size and type for every 50 splices made in the factory and every 10 splices made at the job site shall be furnished for inspection and testing. The spliced samples shall be made using straight run pieces with

the splice located at the mid-length of the sample and finished as required for the installed waterstop. The total length of each splice shall be not less than 12 inches long.

SD-07 Certificates

Preformed Expansion Joint Filler
Compression Seals and Lubricants
Waterstops

Certificates of compliance and certified manufacturer's test reports shall be provided for expansion joint filler strips, compression seals and lubricant and waterstops to verify compliance with applicable specification.

1.3 DELIVERY AND STORAGE

Material delivered and placed in storage shall be stored off the ground and protected from moisture, dirt, and other contaminants. Sealants shall be delivered in the manufacturer's original unopened containers. Sealants whose shelf life has expired shall be removed from the site.

PART 2 PRODUCTS

2.1 PREFORMED EXPANSION JOINT FILLER STRIPS

Expansion joint filler shall be preformed material conforming to ASTM D 1751 or ASTM D 1752, Type I, or resin impregnated fiberboard conforming to the physical requirements of ASTM D 1752.

2.2 JOINT SEALS AND SEALANTS

2.2.1 Field Molded Sealants and Primer

Field molded sealants and primer shall conform to ASTM C 920, Type M, Grade NS, Class 25; use NT for vertical joints and Type M, Grade P, Class 25; use T for horizontal joints. Bond breaker material shall be polyethylene tape, coated paper, metal foil or similar type materials. The back-up material shall be compressible, non-shrink, nonreactive with sealant, and non-absorptive material type such as extruded butyl or polychloroprene rubber.

2.2.2 Compression Seals and Lubricants

Type A joint seals shall consist of a groove in the concrete which is filled with field mixed and placed polyurethane sealant.

Type B seal shall consist of a prefabricated preformed elastromeric joint seal installed in a prepared groove with combination lubricant-adhesive.

2.2.2.1 Type A Seal

Type A seal shall consist of a 2 component polyurethane sealant, which will withstand up to $\pm$ 25 percent movement. The sealant shall be self leveling but cure rapidly enough to avoid flow after application in grades up to 15 percent. The seal when tested in accordance with California Test 435 shall provide Movement Rating (MR) of not less than that shown on the plans.

2.2.2.2 Preformed Elastomeric Joint Seal

The preformed elastomeric joint seal shall conform to ASTM D 2628 and the following. The seal shall consist of a multichannel nonporous, homogeneous material furnished in a finished extruded form. The minimum depth of the seal, measured at the contact surface, shall be at least 95 percent of the minimum uncompressed width of the seal as designated by the manufacture. The seal when tested in accordance with California Test 673 shall provide a Movement Rating (MR) of not less than that shown on the plans. The seal shall be furnished full length for each joint with no more than one shop splice in any 60-foot length of seal. Shop splices shall have no visible offset of exterior surfaces, and shall show no evidence of bond failure.

2.2.2.3 Lubricant-Adhesive

The lubricant-adhesive shall conform to ASTM D 4070 and shall have a viscosity between 20,000 and 300,000 centipoises (cP) when tested in accordance with Section 10.2.1 of ASTM D 4070.

2.3 WATERSTOPS

Non-metallic waterstops shall be manufactured from a prime virgin resin; reclaimed material is not acceptable. The compound shall contain plasticizers, stabilizers, and other additives to meet specified requirements. Polyvinylchloride waterstops shall conform to COE CRD-C 572.

2.4 TEMPERED HARDBOARD

Tempered hardboard shall conform to FS LLL-B-810, Type II, smooth one side, plain. Hardboard shall be 1/8 inch minimum thickness, unless shown or specified otherwise.

2.5 EXPANDED POLYSTYRENE

Expanded polystyrene shall be a commercially available polystyrene board. Expanded polystyrene shall have a flexural strength of 35 pounds per square inch, minimum, determined in accordance with ASTM C 203, and a compressive yield strength of between 16 and 40 pounds per square inch, at 5 percent compression.

2.6 TESTS, INSPECTIONS, AND VERIFICATIONS

2.6.1 Materials Tests

2.6.1.1 Field-Molded Sealants

Samples of sealant and primer, when use of primer is recommended by the manufacturer, as required in paragraph: FIELD-MOLDED SEALANTS AND PRIMER, shall be tested by and at the expense of the Government for compliance with paragraph: FIELD MOLDED SEALANTS AND PRIMER. if the sample fails to meet specification requirements, new samples shall be provided and the cost of retesting will be deducted from payments due the Contractor at a rate of $400.00 per sample.

2.6.1.2 Waterstops

Samples of materials and splices as required in paragraph: WATERSTOPS shall be visually inspected and tested by and at the expense of the Government for. compliance with COE CRD-C 513 or COE CRD-C 572 as applicable. If a sample fails to meet the specification requirements, new samples shall be

provided and the cost of retesting will be deducted from payments due the Contractor at the rate of $700.00 per material sample retested and $110.00 per spliced sample retested.

2.6.2 Splicing Waterstops

2.6.2.1 Procedure and Performance Qualifications

Procedure and performance qualifications for splicing waterstops shall be demonstrated in the presence of the Contracting Officer.

2.6.2.2 Non-Metallic Waterstops

Procedure and performance qualifications for splicing non-metallic waterstops shall be demonstrated by the manufacturer at the factory and the Contractor at the job site by each making three spliced samples of each size and type of finished waterstop.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Contraction Joints

Joints requiring a bond breaker shall be coated with curing compound or with bituminous paint. Waterstops shall be protected during application of bond breaking material to prevent them from being coated.

3.1.2 Expansion Joints

Premolded filler strips shall have oiled wood strips secured to' the top thereof and shall be accurately Positioned and secured against displacement clean, smooth concrete surfaces. The wood strips shall he slightly tapered, dressed and of the size required to install filler strips at the desired level below the finished concrete surface and to form the groove for the joint sealant or seals to the size shown. Material used to secure premolded fille: and wood strips to concrete shall not harm the concrete and shall be compatible with the joint sealant or seals. The wood strips shall not be removed until after the concrete curing period. The groove shall be thoroughly cleaned of all laitance, curing compound, foreign materials, protrusions of hardened concrete and any dust which shall be blown out of the groove with oil-free compressed air.

When expanded polystyrene joint filler is shown on the plans or specified, surfaces of expanded polystyrene shall be faced with hardboard. Other facing materials may be used provided they furnish equivalent protection. All boards shall be held in place by nails, waterproof adhesive, or other means approved by the Contracting Officer.

3.1.2.1 Joints With Type A and B Seals

Grooves for joint seals shall be saw cut to a uniform width and depth and to the alignment shown on the plans or as ordered by the Contracting Officer. Saw cutting of grooves shall not be started until joint seal material has been tested, approved and delivered to the jobsite. Prior to sealing joints, expanded polystyrene, hardboard, concrete spillage and all foreign material shall be removed from the deck joint to the bottom of the saw cut for joints to receive Type A seals, and to the top of the waterstop or a depth of seal plus 3 inches for joints to receive Type B seals. At

least 64 hours prior to placing the seal, the Contractor shall repair all spalls, fractures, breaks or voids in the concrete surfaces of the joint groove. The lip of the saw cut shall be beveled by grinding as shown on the plans. Immediately prior to placing the seal, the joints shall be cleaned by a method that shall include abrasive blast cleaning and then be cleaned with high pressure air jets to remove all residue and foreign material. Waterstops shall be protected from abrasive blast. Joints shall be surface dry at the time seal is placed.

Type B seals shall be installed with equipment which shall be capable of installing joint seals to the prescribed depth without cutting, nicking, twisting, or otherwise distorting or damaging the seal or concrete and with no more than 5 percent stretching of the seal. The sides of the joint and, if necessary, the sides of the compression seal shall be covered with a coating of lubricant, and the seal shall be installed to the depth indicated with joint installation equipment. Butt joints shall be coated with liberal applications of lubricant.

3.1.2.2 Joints With Field-Molded Sealant

Joints shall not be sealed when the sealant material, ambient air, or concrete temperature is less than 40 degrees F. Immediately prior to installation of field molded sealants, the joint shall be cleaned of all debris and further cleaned using water, chemical solvents or other means as recommended by the sealant manufacturer. Joints requiring a bond breaker shall be coated with curing compound or with bituminous paint. Bond breaker and back-up material shall be installed where required. Joints shall be primed and filled flush with joint sealant in accordance with the manufacturer's recommendations.

3.2 WATERSTOPS

3.2.1 General

Waterstops shall be carefully and correctly positioned during installation to eliminate faulty installation that may result in joint leakage. The bottom of each waterstops shall be embedded a minimum of 6 inches in firm rock or sealed to other cutoff systems. All waterstops shall be installed at the locations shown to form a continuous water-tight diaphragm in each joint. Adequate provision shall be made to support and completely protect the waterstops during the progress of the work. Any waterstop punctured or damaged shall be repaired or replaced at the Contractor's expense. Exposed waterstops shall be protected during application of form release agents to avoid being coated. Suitable guards shall be provided to protect exposed projecting edges and ends of partially embedded waterstops from damage when concrete placement has been discontinued. Splices shall be made by certified trained personnel using approved equipment and procedures.

3.2.2 Splices

Joints in waterstops shall be spliced together by qualified splicers using th approved splicing procedures to form a continuous watertight diaphragm. Splices shall he made by heat sealing the adjacent surfaces in accordance wit the approved procedure. A thermostatically controlled electrical heat source shall be used to make all splices. The correct temperature at which splices should be made will differ with the material concerned but the applied heat should be sufficient to melt but not char the plastic. Waterstops shall be reformed at splices with a remolding iron with ribs or corrugations to match the pattern of the waterstop. The spliced area, when

cooled and bent by hand in as sharp an angle as possible, shall show no sign of separation.

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DIVISION 03 - CONCRETE

SECTION 03200

CONCRETE REINFORCEMENT

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SECTION 03200

CONCRETE REINFORCEMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 318/318R	(1995) Building Code Requirements for Structural Concrete and Commentary

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 82	(1997a) Steel Wire, Plain, for Concrete Reinforcement
ASTM A 185	(1997) Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
ASTM A 615/A 615M	(1996a) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 706/A 706M	(1998) Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4	(1998) Structural Welding Code - Reinforcing Steel

CALIFORNIA STATE DEPARTMENT OF TRANSPORTATION (CALTRANS)

CALTRANS SHS-1	(1992) Standard Specifications

CONCRETE REINFORCING STEEL INSTITUTE (CRSI)

CRSI MSP-1 (1996) Manual of Standard Practice

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Reinforcement System; G

Two reproducibles and four copies of reinforcement placing drawings containing all of the information necessary for placing and checking specified or authorized reinforcement steel in the field at least 30 days before placement. The drawings shall show the outline of the structure, size, grade, identity, quantity, and spacing of the bars, orientation of the mat (example: near face or far face, top or bottom), minimum and/or maximum concrete cover and any other details required for placing the reinforcement. The use of standard symbols and abbreviations referenced in ACI 315 is acceptable. Use of other symbols must be approved in writing. The scale used in preparing the drawings shall be large enough to show all details clearly. All bars, both straight and bent, shall be given an identifying mark number. The quantity of specific bars shall be indicated only once on each drawing even though the bars may be shown more than once (example: a group of bars with the same mark number may be shown in both the plan view and sectional view an the drawings. The bars would be identified by mark number on both views but the quantity of bars and splicing details required would be indicated on only one of the views). Bending details for bent bars and splicing details shall be shown on the reinforcement placement drawing if not detailed on the bar lists.

Bar List; G

Two reproducibles and two copies of a separate bar list (may contain more than one sheet) which shows all bars to be embedded for each concrete placement (lift) at least 30 days before placement. A bar list common to two or more placements is acceptable. The bar lists shall be 8-1/2 inches by 14 inches in size. The bar list shall contain the Contractor's name; contract name and number; bar list number; weight of bars by size and total weight of bars; description or mark number, size, grade total length, and bend diagram; reference to placing drawing and section or plan in the drawing for each group of similar bars; space for numbers and dates of revision the bar list; and space for signature of the Contractor and Contracting Officer with dates.

SD-03 Product Data

Welding; G

A list of qualified welders names.

SD-07 Certificates

Reinforcing Steel

Certified copies of mill reports attesting that the reinforcing steel furnished contains no less than 25 percent recycled scrap steel and meets the requirements specified herein, prior to the installation of reinforcing steel.

Test Reports

Certified test reports of reinforcement steel showing that the materials comply. Reports shall be identified with specific lots and shall be furnished for each steel shipment prior to use of the steel in the work. The results of bend-tests, tension tests, and other tests required by the appropriate ASTM designation shall be submitted, or as hereafter specified.

Chemical Composition of Reinforcement Steel, G

Three copies of the ladle analysis of each lot of reinforcement steel. A certification shall be obtained from the manufacturer that the steel furnished conforms to the ladle analysis. The ladle analysis shall state the percentage of carbon, phosphorus, manganese and sulfur present in the steel.

1.3 WELDING

Welders shall be qualified in accordance with AWS D1.4. Qualification test shall be performed at the worksite and the Contractor shall notify the Contracting Officer 24 hours prior to conducting tests. Special welding procedures and welders qualified by others may be accepted as permitted by AWS D1.4.

1.4 DELIVERY AND STORAGE

Reinforcement and accessories shall be stored off the ground on platforms, skids, or other supports.

PART 2 PRODUCTS

2.1 REINFORCING STEEL

Reinforcing steel shall be deformed bars conforming to ASTM A 615/A 615M or ASTM A 706/A 706M, grades and sizes as indicated. Cold drawn wire used for spiral reinforcement shall conform to ASTM A 82.

2.2 WELDED WIRE FABRIC

Welded wire fabric shall conform to ASTM A 185.

2.3 WIRE TIES

Wire ties shall be 16 gauge or heavier black annealed steel wire.

2.4 SUPPORTS

Bar supports for formed surfaces shall be designed and fabricated in accordance with CRSI MSP-1 and shall be steel or precast concrete blocks. Precast concrete blocks shall have wire ties and shall be not less than 4

inches square when supporting reinforcement on ground. Precast concrete block shall have compressive strength equal to that of the surrounding concrete. Where concrete formed surfaces will be exposed to weather or where surfaces are to be painted, steel supports within 1/2 inch of concrete surface shall be galvanized, plastic protected or of stainless steel. Concrete supports used in concrete exposed to view shall have the same color and texture as the finish surface. For slabs on grade, supports shall be precast concrete blocks, plastic coated steel fabricated with bearing plates, or specifically designed wire-fabric supports fabricated of plastic.

PART 3 EXECUTION

3.1 REINFORCEMENT

Reinforcement shall be fabricated to shapes and dimensions shown and shall conform to the requirements of ACI 315 and ACI 318/318R. Reinforcement shall be cold bent unless otherwise authorized. Bending may be accomplished in the field or at the mill. Bars shall not be bent after embedment in concrete. Safety caps shall be placed on all exposed ends of vertical concrete reinforcement bars that pose a danger to life safety. Wire tie ends shall face away from the forms. Additional requirements for bundled bars shall comply with CALTRANS SHS-1.

3.1.1 Placement

Reinforcement shall be free from loose rust and scale, dirt, oil, previously placed concrete, or other deleterious coating that could reduce bond with the concrete. Reinforcement shall be placed in accordance with ACI 318/318R at locations shown plus or minus one bar diameter. Reinforcement shall not be continuous through expansion joints and shall be as indicated through construction or contraction joints. Concrete coverage shall be as indicated or as required by ACI 318/318R. If bars are moved more than one bar diameter to avoid interference with other reinforcement, conduits or embedded items, the resulting arrangement of bars, including additional bars required to meet structural requirements, shall be approved before concrete is placed.

3.1.2 Welding

Welding of reinforcement bars will be permitted only as shown or as otherwise directed. Unless specifically shown, arc-welding of crossing bars, ties, stirrups, spirals or any other reinforcement will not be permitted. Welding shall be performed in accordance with AWS D1.4, except where otherwise specified.

3.1.3 Placing Tolerances

3.1.3.1 Spacing of Bars

Bars shall be spaced as shown. The spacing between adjacent bars and the distance between layers may not vary from the indicated position by more than one bar diameter nor more than 1 inch.

3.1.3.2 Concrete Cover

The concrete cover placing tolerance of main reinforcement shall be as follows:

MINIMUM COVER	VARIATION
6 inches	+ 1/2 inch
4 inches	+ 3/8 inch
3 inches	+ 3/8 inch
2 inches or less	+ 1/4 inch

3.1.4 Splicing

Splices of reinforcement shall conform to ACI 318/318R and shall be made only as required or indicated. Splicing shall be by lapping or by mechanical or welded butt connection; except that lap splices shall not be used for bars larger than No. 11 unless otherwise indicated. Welding shall conform to AWS D1.4. Welded butt splices shall be full penetration butt welds. Lapped bars shall be placed in contact and securely tied or spaced transversely apart to permit the embedment of the entire surface of each bar in concrete. Lapped bars shall not be spaced farther apart than one-fifth the required length of lap or 6 inches. Mechanical butt splices shall be in accordance with the recommendation of the manufacturer of the mechanical splicing device. Butt splices shall develop 125 percent of the specified minimum yield tensile strength of the spliced bars or of the smaller bar in transition splices. Bars shall be flame dried before butt splicing. Adequate jigs and clamps or other devices shall be provided to support, align, and hold the longitudinal centerline of the bars to be butt spliced in a straight line.

3.2 WELDED-WIRE FABRIC PLACEMENT

Welded-wire fabric shall be placed in slabs as indicated. Fabric placed in slabs on grade shall be continuous between expansion, construction, and contraction joints. Fabric placement at joints shall be as indicated. Lap splices shall be made in such a way that the overlapped area equals the distance between the outermost crosswires plus 2 inches. Laps shall be staggered to avoid continuous laps in either direction. Fabric shall be wired or clipped together at laps at intervals not to exceed 4 feet. Fabric shall be positioned by the use of supports.

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DIVISION 03 - CONCRETE

SECTION 03230

STEEL STRESSING TENDONS AND ACCESSORIES FOR PRESTRESSED CONCRETE

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SECTION 03230

STEEL STRESSING TENDONS AND ACCESSORIES FOR PRESTRESSED CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 315	(1992) ACI Detailing Manual: Section Details and Detailing of Concrete Reinforcement
ACI 318/318R	(1995) Building Code Requirements for Structural Concrete and Commentary

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 416/A 416M	(1996) Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
ASTM A 421	(1991) Uncoated Stress-Relieved Steel Wire for Prestressed Concrete
ASTM A 722/A 722M	(1995) Uncoated High-Strength Steel Bar for Prestressing Concrete

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G

Installation drawings for tendons and accessories shall be submitted and approved prior to commencing the work.

SD-03 Product Data

Prestressing Method and Equipment; G

Descriptions of proposed prestressing method and equipment shall be submitted and approved prior to the start of prestressing operations.

Materials Disposition Records

Records which identify the incorporation of approved materials into the work shall be submitted before completion of the contract.

Prestressing Operations Records

Complete records of the prestressing operations shall be submitted before completion of the contract.

SD-06 Test Reports

Stressing Tendons and Accessories

Certified materials test reports shall be submitted for all required materials tests, note the specific standards followed in the performance of tests, show that materials comply with the applicable specifications, be submitted for each material shipment and be identified with specific lots prior to use of materials in the work.

SD-07 Certificates

Certification of Prestressing Technicians

Certificates for prestressing technicians shall be submitted prior to start of prestressing operations.

1.3 CERTIFICATION OF PRESTRESSING TECHNICIANS

Submitted certificates for prestressing technicians who will use the proposed system in the work shall certify by name that these technicians are thoroughly trained and skilled in the use of the system.

1.4 DELIVERY, STORAGE AND HANDLING OF MATERIALS

Materials shall be suitably wrapped, packaged or covered at the factory to prevent being affected by dirt, water and rust. Materials shall be protected against abrasion or damage during shipment and handling. Materials stored at the site shall be placed above ground on elevated, covered platforms.

PART 2 PRODUCTS

2.1 MATERIALS

Stressing tendons and accessories shall conform to the requirements of ACI 318/318R except as specified.

2.1.1 Stressing Tendons

Stressing tendons shall be clean and free of loose rust, scale and pitting. Unbonded tendons shall be permanently protected from corrosion with an approved applied coating.

2.1.1.1 Seven-Wire Stress-Relieved Strand and Strand Assemblies

Seven-wire stress-relieved strand and strand assemblies shall conform to ASTM A 416/A 416M, Grade 270, strand diameter as shown. Strand assemblies

may be either shop or field assembled with anchor fittings positively attached to strands.

2.1.1.2 Stress-Relieved Wire and Wire Assemblies

Stress-relieved wire and wire assemblies shall conform to ASTM A 421, Type BA or WA, wire diameter as shown. Wire assemblies shall be shop assembled with anchor fittings positively attached to wires.

2.1.1.3 High-Strength Steel Bars

High-strength steel bars shall conform to ASTM A 722/A 722M, Type I or II, meeting all supplementary requirements.

2.1.2 Accessories

2.1.2.1 Anchorages and Couplers

Anchorages and couplers shall be metal of proven corrosion resistance and compatible with the stressing tendons, capable of fully developing the minimum guaranteed ultimate strength of tendons without excessive slip and approved. Anchorages shall be the button-head, wedge, nut and thread, grip nut, thread-bar, threaded plate or other approved type and shall be provided with bearing plates bars, rings, bells or other positive-attaching anchor fittings. Couplers shall be provided with housings long enough to permit the necessary movements and fittings which allow complete grouting of all components.

2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

The Contractor shall have required material tests performed on stressing tendons and accessories by an approved laboratory to demonstrate that the materials are in conformance with the specifications. These tests shall be at the Contractor's expense.

PART 3 EXECUTION

3.1 INSTALLATION

Stressing tendons and accessories shall be installed or placed as specified and as shown on contract and approved installation drawings. Installation details of stressing tendons and accessories not specified or shown shall be in accordance with ACI 315 or ACI 318/318R. Welding shall not be performed near or adjacent to stressing tendons. Stressing tendons shall not be installed until all welding has been completed on supports or any part which might be in contact with the tendons.

3.1.1 Prestressing Method and Equipment

Descriptions of the proposed prestressing methods and equipment indicating the manufacturer of all prestressing equipment, including tensioning jacks, stress measurement gages, dynamometers and load cells or other devices for measuring stressing loads, shall be provided by the contractor. Descriptions shall include certified calibration records for each set of jacking equipment and testing curves for stress measurement gages which show that the gages have been calibrated for the jacks for which they are to be used.

3.1.2 Installation Drawings

Detailed installation drawings for stressing tendons and accessories showing the type and size of stressing tendons and anchorages, erection methods, sequence of stressing and stressing calculations shall be provided by the Contractor.

3.1.3 Anchorages

Anchorages must be set in a plane normal to the axis of the tendons such that uniform bearing on the concrete is assured. Positive connecting anchorages rather than gripping types shall be used for anchoring embedded ends of tendons. Anchorages and anchor fittings shall be permanently protected against corrosion. Parallel wire anchorage wedges or cores shall be recessed within the members.

3.1.4 Stressing Tendons and Ducts

Protective coverings and wrappings shall be removed and each stressing tendon shall be closely inspected to see that nicks, scoring, pits or other damage does not exist and high strength steel bars shall be closely inspected to assure that they are not bent and that threaded ends are in satisfactory condition immediately prior to installation. Strand, wire and bar tendons shall be shop or field assembled as required and positively attached to anchorages. Type WA wire assemblies shall be anchored only with wedge type anchorages. Stressing tendons and ducts shall be assembled to required shapes and dimensions and placed where indicated on drawings within specified tolerances and adequately supported. Strands to be spliced shall have the same lay or direction of twist and the ends shall be cut by shears or abrasive grinders. No more than one strand shall be spliced in any one member where single strand tensioning is employed. Strand splices shall be capable of developing the full ultimate strength of the strand. Slippage of the splice shall be checked and correction made for differential slippage. Where multiple strand tensioning is used, not more than 10 percent of the strands in any member shall be spliced.

3.1.5 Tensioning Tendons

Tensioning of stressing tendons shall be as specified and shown. The stress induced in the tendons by any method of tensioning shall be determined independently by both (1) measurement of tendon elongation and (2) direct measurement of force using a pressure gauge or load cell. If the results of these two measurements do not check each other and the theoretical values within 5 percent, the operation shall be carefully checked and the source of error determined and corrected before proceeding further. Concrete cylinder tests shall indicate a breaking strength of at least 4000 psi before transfer of stress to ensure that the concrete strength is adequate for the requirements of the anchorages or for transfer through bond as well as meet camber or deflection requirements. Determination of the initial prestress force must consider prestress losses in accordance with CALTRANS SHS-1 Standard Specifications for Bridges, Section 50. The final prestress load in each unit after seating shall be as shown. Safety measures shall be taken by the Contractor to prevent accidental injury caused by failure of a stressing tendon or tendon component. The exposed ends of stressing tendons and anchorages shall be protected from damage during stressing operations to prevent failure.

3.1.5.1 Pretensioning

Strand tendons may be tensioned by jacking of groups of strands or may be

tensioned individually by means of a single-strand jack. Before final tensioning, all tendons shall be brought to a uniform initial tension of approximately 1,000 pounds per strand per 200 feet of bed, with a minimum of 1,000 pounds and a maximum of 3,000 pounds per strand. The force corresponding to the initial tension shall be measured by a dynamometer or other approved method to aid in determining the final elongation. After this initial tensioning, the tendons shall be stressed to the total tension indicated on the drawings using hydraulic or mechanical equipment with gauges or dynamometers graduated and calibrated to accurately determine the load applied. Draped pretensioned strands shall be tensioned partially by jacking at the end of the bed and partially by uplifting or depressing strands, or they shall be held in their draped positions by means of rollers, pins or other approved methods and tensioned entirely by jacking. Approved low-friction devices shall be used at all points of change in slope of draped strands while tensioning draped strands, regardless of the tensioning method used. Cable stress shall be maintained between anchorages until the concrete has reached the specified compressive strength.

3.1.5.2 Detensioning

Forces from pretensioned strands shall be transferred to the concrete by either the multiple-strand release or the single-strand release method. The stress transfer shall not be performed until concrete strength, as indicated by test cylinders, has reached the specified transfer strength. If concrete has been heat-cured, the detensioning shall be done immediately following the curing period while the concrete is still warm and moist. During detensioning, the prestressing forces shall be kept nearly symmetrical about the vertical axis of the member and shall be applied in a manner that will minimize sudden loading. Eccentricity about the vertical axis shall be limited to one strand.

a. Multiple-Strand Release: In this method, all strands shall be detensioned simultaneously and the load transferred gradually to the concrete by hydraulic jacking.

b. Single-Strand Release: In this method, all strands shall be detensioned by slow heat-cutting the strands in accordance with a pattern and schedule as approved. The strands shall be heated using a low-oxygen flame until the metal gradually loses its strength, causing release of the strands to occur gradually. The low-oxygen flame shall be played along the strand for a minimum of five inches. Strands shall be so heated that the failure of the first wire in each strand shall occur after the torch has been applied for a minimum of five seconds.

3.1.6 Accuracy of Stress and Elongation Measurement

3.1.6.1 Stress Measurement

Hydraulic gauges, dynamometers, load cells or other devices for measuring stressing load shall have an accuracy of reading within two percent for stress measurement. Gauges are required to have been calibrated for the jacks for which they are used within a period not exceeding 12 months. Recalibration shall be performed at any time that a gaging system shows indication of erratic results in the opinion of the Contracting Officer. Gauges shall indicate loads directly in pounds or be accompanied by a chart which converts dial readings into pounds.

3.1.6.2 Elongation Measurement

After the initial force has been applied to a tendon, reference points for measuring elongation due to additional tensioning forces shall be established. They shall be located according to the method of tensioning and type of equipment. The system used shall be capable of measuring the true elongation plus or minus 1/16-inch.

3.1.7 Prestressing Operations Records

The Contractor shall compile and submit complete prestressing operations records to the Contracting Officer. These records shall show the manufacturer, identification and description of materials and equipment including prestressing tendons and jacking and load measuring equipment; location of prestressing tendons; initial design tensioning loads, final design tensioning loads and actual tensioning loads for tendons; dates tensioning loads applied; and theoretical and actual elongations for tendons.

3.2 INSPECTION

The Contractor's facilities shall be open for inspection by the Contracting Officer at any time.

3.3 MATERIALS DISPOSITION RECORDS

Accurate materials disposition records identifying all materials incorporated into the work and showing the disposition of specific lots of approved tested materials shall be compiled by the Contractor.

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DIVISION 03 - CONCRETE

SECTION 03305

CAST-IN-PLACE STRUCTURAL CONCRETE

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SECTION 03305

CAST-IN-PLACE STRUCTURAL CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 117/117R	(1990; Errata) Standard Tolerances for Concrete Construction and Materials
ACI 211.1	(1991) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 214	(1977; R 1989) Recommended Practice for Evaluation of Strength Test Results of Concrete
ACI 305R	(1991) Hot Weather Concreting
ACI 318/318R	(1995) Building Code Requirements for Structural Concrete and Commentary
ACI 503.2	(1992; R 1997) Standard Specification for Bonding Plastic Concrete to Hardened Concrete with a Multi-Component Epoxy System

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A137.1	(1988) Ceramic Tile

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31	(1998) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(1997) Concrete Aggregates
ASTM C 39	(1996) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 40	(1992) Organic Impurities in Fine Aggregates for Concrete
ASTM C 42	(1994) Obtaining and Testing Drilled Cores and Sawed Beam of Concrete

ASTM C 94	(1998c) Ready-Mixed Concrete
ASTM C 117	(1995) Materials Finer Than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 127	(1988; R 1993) Specific Gravity and Absorption of Course Aggregate
ASTM C 128	(1993) Specific Gravity and Absorption of Fine Aggregate
ASTM C 131	(1996) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 142	(1978; R 1990) Clay Lumps and Friable Particles in Aggregates
ASTM C 143	(1997) Slump of Hydraulic Cement Concrete
ASTM C 150	(1997) Portland Cement
ASTM C 171	(1992) Sheet Materials for Curing Concrete
ASTM C 172	(1997) Sampling Freshly Mixed Concrete
ASTM C 192	(1995) Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	(1997e1) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 309	(1995) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 494	(1998) Chemical Admixtures for Concrete
ASTM C 535	(1989) Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 566	(1989) Total Moisture Content of Aggregate by Drying
ASTM C 597	(1983; R 1991) Pulse Velocity Through Concrete
ASTM C 618	(1997) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C 803	(1990) Penetration Resistance of Hardened Concrete

ASTM C 805	(1994) Rebound Number of Hardened Concrete
ASTM C 881	(1990) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 928	(1992a) Packaged Dry, Rigid-Hardening Cementitious Materials for Concrete Repairs
ASTM C 937	(1980; R 1991) Grout Fluidifier for Preplaced-Aggregate Concrete
ASTM C 989	(1997) Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM C 1059	(1991) Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C 1064	(1986; R 1993) Temperature of Freshly Mixed Portland Cement Concrete
ASTM C 1077	(1998) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1107	(1991a) Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM D 75	(1987; R 1992) Sampling Aggregates
ASTM D 4791	(1995) Flat or Elongated Particles in Coarse Aggregate

CORPS OF ENGINEERS (COE)

COE EM 1110-2-2000	Engineering and Design - Standard Practice for Concrete
COE CRD-C 55	(1995) Within-Batch Uniformity of Freshly Mixed Concrete
COE CRD-C 94	(1995) Specifications for Surface Retarders
COE CRD-C 100	(1975) Method of Sampling Concrete Aggregate and Aggregate Sources, and Selection of Material for Testing
COE CRD-C 104	(1980) Method of Calculation of the Fineness Modulus of Aggregate
COE CRD-C 143	(1962) Specifications for Meters for Automatic Indication of Moisture in Fine Aggregate
COE CRD-C 318	(1979) Cloth, Burlap, Jute (or Kenaf)
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete

COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(1994) NIST Handbook 44: Specifications, Tolerances, and other Technical Requirements for Weighing and Measuring Devices

NATIONAL READY-MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(1990) Concrete Plant Standards

1.2 GOVERNMENT TESTING AND STUDIES

1.2.1 Preconstruction Testing and Mixture-Proportioning Studies

1.2.1.1 Aggregates

The aggregate sources listed in paragraph: MATERIAL SPECIFICATION, have been tested, and at the time testing was performed, these sources were capable of producing materials of the quality and quantity required for this project provided suitable processing is performed. Samples from any source selected consisting of not less than 100 pounds of each size of coarse aggregate and 250 pounds of fine aggregate, taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100, shall be delivered to the US Army Corps of Engineers, Engineering Research and Development Center (ERDC), 3909 Halls Ferry Road, Vicksburg MS, 39180-6199, ATTN:Toy Poole, CEERD-GM-C; within 15 days after notice to proceed. Sampling and shipment of samples shall be at the Contractor's expense. 60 days will be required to complete evaluation of the aggregates. Testing will be performed by the Government in accordance with the applicable COE CRD-C or ASTM test methods. Tests to which aggregate may be subjected are listed in paragraph: MATERIAL SPECIFICATION. The material from the proposed source shall meet the quality requirements of this paragraph to be used for the project. The Government test data and other information on aggregate quality of those sources listed in paragraph: MATERIAL SPECIFICATION, and are available for review in the District Office. Quality assurance testing of aggregates by the Government does not relieve the Contractor of quality control requirements.

1.2.1.2 Cementitious Materials, Admixtures, and Curing Materials

Notify the Contracting Officer of the source, brand name, type, and quantity of all materials (other than aggregates) to be used in the manufacture and curing of the concrete at least 60 days in advance of submitting samples for mixture proportioning studies. The Contractor shall assist the Contracting Officer in obtaining samples of each material. Sampling and testing as determined appropriate will be performed by and at the expense of the Government. If cement or pozzolan are to be obtained from more than one source, the notification shall state the estimated amount of cement or pozzolan to be obtained from each source and the proposed schedule of shipments. When pozzolan other than fly ash is used, it shall be from one source.

1.2.1.3 Materials for Mixture-Proportioning Studies

At least 135 days in advance of the time when placing of concrete is

expected to begin, samples of representative materials proposed for this project and meeting all the requirements of this specification shall be delivered to US Army Corps of Engineers, Engineering Research and Development Center (ERDC), 3909 Halls Ferry Road, Vicksburg MS, 39180-6199, ATTN:Toy Poole, CEERD-GM-C, by the Contractor at his expense. Samples of aggregates shall be taken under the supervision of the Contracting Officer in accordance with COE CRD-C 100, accompanied by test reports indicating conformance with grading and quality requirements hereinafter specified. Samples of materials other than aggregates shall be representative of those proposed for the project and shall be submitted accompanied by manufacturer's test reports indicating compliance with applicable specified requirements. Quantities of materials required shall be as follows:

MATERIAL	QUANTITY
1-1/2 inch nominal maximum-size coarse aggregate	7,000 pounds
3/4 inch nominal maximum-size coarse aggregate	8,000 pounds
Fine aggregate	11,000 pounds
Cement	4,000 pounds
Pozzolans	1,500 pounds
Ground Granulated Blast Furnace Slag	4,000 pounds
Chemical Admixtures (each)	5 gallons

Mixture-proportioning studies will be made by the Government at its expense.

1.2.2 Construction Testing by the Government

1.2.2.1 General

The Government will sample and test cementitious materials, admixtures, aggregates, and concrete during construction as considered appropriate to determine compliance with the specifications. The Contractor shall provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with COE CRD-C 100. Slump will be determined in accordance with ASTM C 143, except the point of sampling will be as directed. Compression test specimens will be made and laboratory cured in accordance with ASTM C 31 and will be tested in accordance with ASTM C 39.

1.2.2.2 Testing Aggregates

Testing performed by the Government will not relieve the Contractor of his responsibility for testing as appropriate for quality control. During construction, aggregates will be sampled for acceptance testing as delivered to the mixer to determine compliance with specification provisions. The Contractor shall provide necessary facilities and labor for the ready procurement of representative samples under Contracting Officer supervision. The Government will test such samples at its expense using appropriate COE CRD-C and ASTM methods.

1.2.2.3 Cementitious Materials

Cement or pozzolan or both shall be furnished from a prequalified source

or, if not, it (they) will be sampled at the mill, shipping point, or site of the work by the Contracting Office. A list of prequalified cement sources and prequalified pozzolan sources is available from the Director, U.S. Army Engineer Waterways Experiment Station (CEWES-SC-MP), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199. If tests prove that a material which has been delivered is unsatisfactory, it shall be promptly removed from the site of the work. Cementitious materials that have not been used within 6 months after being tested will be retested by the Government at the expense of the Contractor when directed.

1.2.2.4 Cement from Prequalified Sources

Cement shall be delivered and used directly from a mill of a producer designated as a prequalified source for the type of cement being used. Samples of cement for quality-assurance testing will be taken at the project site or cement-producing plant by the Contracting Officer for testing at the expense of the Government. A copy of the mill tests from the cement manufacturer shall be furnished to the Contracting Officer for each lot.

1.2.2.5 Pozzolan from Prequalified Sources

Pozzolan shall be delivered and used directly from a producer designated as a prequalified source. Samples of pozzolan for check testing will be taken at the project site by the Contracting Officer for testing at the expense of the Government. A copy of the test results from the pozzolan manufacturer shall be furnished to the Contracting Officer for each lot.

1.2.2.6 Cement from Nonprequalified Sources

Cement, if not from a prequalified source, will be sampled and tested by or under the supervision of the Contracting Officer and at Government expense. No cement shall be used until notice has been given by the Contracting Officer that test results are satisfactory. In the event of failure, the cement may be resampled and tested at the request of the Contractor and at the Contractor's expense. When the point of sampling is other than at the site of the work, the fill gate or gates of the sampled bin will be sealed and kept sealed until shipment from the bin has been completed. The fill gate or gates of conveyances used in shipment will be sealed by or under the supervision of the Contracting Officer. Conveyances will not be accepted at the site of the work unless received with all seals intact. If tested cement is rehandled at transfer points, the extra cost of inspection will be at the Contractor's expense. The cost of testing cement excess to project requirements will also be at the Contractor's expense and will be deducted from payments due the Contractor at a rate of 1750 dollars per test.

1.2.2.7 Pozzolan from Nonprequalified Sources

Pozzolan, if not from a prequalified source, will be sampled at the source or at the site of the work and will be stored in sealed bins pending completion of acceptance tests. Pozzolan may be resampled at the site when determined necessary. All sampling and testing will be performed by and at the expense of the Government. Release for shipment and approval for use will be based on compliance with seven day strength activity index requirements, with portland cement; and other physical; chemical; and uniformity requirements for which tests can be completed by the time the seven day strength activity index test is completed. Release for shipment and approval for use on this basis will be contingent on continuing

compliance with the other requirements of the specifications. If test results of a bin fail, the contents may be resampled and tested at the Contractor's expense. The Government will supervise or perform the unsealing and resealing of bins and shipping conveyances. If tested pozzolan is rehandled at transfer points, the extra cost of inspection will be at the Contractor's expense. The cost of testing excess pozzolan in excess of project requirements will be at the Contractor's expense at a rate of 1650 dollars per test. The amount will be deducted from payment to the Contractor.

1.2.2.8 Ground Granulated Blast-Furnace Slag

Ground granulated blast-furnace slag will be sampled and tests at the mill or shipping point by and at the expense of the Government to determine that the material meets the requirements of the specification under which it is furnished. No ground granulated blast-furnace slag shall be used until notice of acceptance has been given by the Contracting Officer. Ground granulated blast-furnace slag will be subject to check testing from samples obtained at the project site, as scheduled, and such sampling will be by or under the supervision of the Contracting Officer and at Government expense. Material not meeting specifications shall be promptly removed from the site of work.

1.2.2.9 Chemical Admixtures

The Contractor shall provide satisfactory facilities for ready procurement of adequate test samples. All sampling and testing of a chemical admixture will be by and at the expense of the Government. Tests will be conducted using samples of materials proposed for the project.

1.2.2.10 Concrete Strength

Compressive strength test specimens will be made by the Government and cured in accordance with ASTM C 31 and tested in accordance with ASTM C 39. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'c and no individual test result falls below the specified strength f'c by more than 500 psi. A "test" is defined as the average of two companion cylinders, or if only one cylinder is tested, the results of the single cylinder test. Additional analysis or testing, including nondestructive testing, taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the structure is considered potentially deficient.

a. Investigation of Low-Strength Test Results - When any strength test of standard-cured test cylinders falls below the specified strength requirement by more than 500 psi or if tests of field-cured cylinders indicate deficiencies in protection and curing, steps shall be taken to assure that the load-carrying capacity of the structure is not jeopardized. Nondestructive testing in accordance with ASTM C 597, ASTM C 803, or ASTM C 805 may be permitted by the Contracting Officer to estimate the relative strengths at various locations in the structure as an aid in evaluating concrete strength in place or for selecting areas to be cored. Such tests shall not be used as a basis for acceptance or rejection.

b. Testing of Cores - When the strength of concrete in place is considered potentially deficient, cores shall be obtained and

tested in accordance with ASTM C 42. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the performance of the structure. Concrete in the area represented by the core testing will be considered adequate if the average strength of the cores is equal to at least 85 percent of the specified strength requirement and if no single core is less than 75 percent of the specified strength requirement.

c. Load Tests - If the core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be directed by the Contracting Officer in accordance with the requirements of ACI 318/318R. Concrete work evaluated by structural analysis or by results of a load test shall be corrected in a manner satisfactory to the Contacting Officer. All investigations, testing, load tests, and correction of deficiencies will be performed and approved by the Contracting Officer at the expense of the Contractor, except that if all concrete is in compliance with the plans and specifications, the cost of investigations, testing, and load tests will be at the expense of the Government.

1.3 DESIGN REQUIREMENTS

The following requirements are for mixture proportions prepared by the contractor.

1.3.1 Concrete Strength

Minimum specified compressive strength f'c shall be as follows:

COMPRESSIVE STRENGTH (PSI)	STRUCTURE OR PORTION OF STRUCTURE
4,000 @ 28 days*	Intake structure, transition structure, outlet conduit, stilling basin, and parabolic drop structure
4,000 @ 28 days	Bridge elements, precast elements, generator and gaging station building foundation, and structural elements not described below
3,250 @ 28 days	Bridge footings and bridge retaining walls
3,000 @ 28 days	Runout channel, outlet channel, and concrete not described elsewhere
2,500 @ 28 days	Temporary concrete
2,000 @ 28 days	Lean mix concrete

* Concrete used in parts of these structures will be proportioned by the Contracting Officer.

1.3.2 Maximum Water-Cement (W/C) Ratio

Maximum W/C shall be as follows:

WATER-CEMENT RATIO, BY MASS	STRUCTURE OR PORTION OF STRUCTURE
0.45	Intake structure, transition structure, outlet conduit, stilling basin, and parabolic drop structure
0.50	Permanent concrete construction exposed to soils or water not described elsewhere
0.50	Bridge deck slabs, prestressed and precast members, and generator and gaging station building foundation
0.55	Other portions of bridge structures
0.65	Temporary concrete, lean mix concrete and concrete not described elsewhere

These W/C's may cause higher strengths than that required by paragraph: CONCRETE STRENGTH.

1.4 CONSTRUCTION TOLERANCES

1.4.1 General

Level and grade tolerance measurements of slabs shall be made as soon as possible after finishing. When forms or shoring are used, the measurements shall be made prior to removal. Tolerances are not cumulative. The most restrictive tolerance controls. Tolerances shall not extend the structure beyond legal boundaries. Except as specified otherwise, plus tolerance increases the amount or dimension to which it applies, or raises a level alignment and minus tolerance decreases the amount or dimension to which it applied, or lowers a level alignment. A tolerance without sign means plus or minus. Where only one signed tolerance is specified, there is no limit in the other direction. The unformed finished surfaces subject to high-velocity flow (40 fps) shall be finished to meet the tolerances for A-HV surfaces specified in Table, "TOLERANCES FOR FINISHED FORMED CONCRETE SURFACES".

The definitions of the terms used in the following tabulations are used as defined and used in ACI 117/117R. Level and grade tolerance measurements of slabs shall be made as soon as possible after finishing.

TABLE I. CONSTRUCTION TOLERANCES FOR INTAKE STRUCTURE

(a)	Variation of the constructed linear outline from the established position in the plan	20 feet..... 1/2 inch Maximum..... 1 inch
(b)	Variation in dimensions to individual structure features from established positions	In 80 feet or more.... 1 inch In buried construction And bulkhead faces.... 2 inches
(c)	Variation from the plumb, from the specified batter, or from the curved surfaces of all structures, including the lines	In any 10 feet. .....2 inch In any 20 feet. .....3/4 inch Maximum..... .. 1-1/4 inches In buried .... Twice

TABLE I. CONSTRUCTION TOLERANCES FOR INTAKE STRUCTURE

	and surfaces of columns, walls, piers, buttresses, arch sections, vertical joint grooves, and visible arises	construction	the above amounts
(d)	Variation from the level or from the grades indicated ion the drawings in slabs, beams, soffits, horizontal joint grooves, and visible arises	In any 10 feet..... In any 30 feet or more. In buried construction.	5/16 inch 1/2 inch Twice the above amounts
(e)	Variation in cross-sectional dimensions of columns, beams, wet well walls, and similar members	Minus..... Plus.....	1/4 inch 1/2 inch
(f)	Variation in the thickness of slabs, walls, arch sections, and similar members	Minus..... Plus.....	1/4 inch 1/2 inch
(g)	Variation in the sizes and locations of sleeves, floor openings, and wall openings	.....	1/4 inch
(h)	For watertight joints such as guides and sill areas, variations from the plumb and level	Not greater than 1/8 inch In 10 feet	

TABLE II. TOLERANCES FOR OTHER THAN INTAKE STRUCTURE

(a)	Variation of the constructed linear outline from the established position in the plan	20 feet..... Maximum..... .	1/2 inch 1 inch
(b)	Variation in dimensions to individual structure features from established positions	Maximum..... In flow areas.....	1/2 inch 1/4 inch
(c)	Variation from the plumb, from the specified batter, or from the curved surfaces	In any 10 feet..... Maximum.....	1/2 inch 1 inch
(d)	Variation from the level or from the grades indicated on the drawings in slabs, beams, water conveying conduits, soffits, horizontal joint grooves, and visible arises	In any 10 feet..... In any 30 feet or more.	5/16 inch 1/2 inch
(e)	Variation in cross-sectional dimensions of columns, beams, walls, and similar members	Minus..... Plus.....	1/4 inch 1/2 inch
(f)	Variation in the sizes and locations of sleeves and	.....	1/4 inch

TABLE II. TOLERANCES FOR OTHER THAN INTAKE STRUCTURE

	openings in floors, roofs, and walls	

TABLE III. TOLERANCES FOR BRIDGES

(a)	Departure from established alignment	..... 1 inch
(b)	Departure from established grades	..... 1 inch
(c)	Variation in cross-sectional dimensions of columns, piers, slabs, walls, beams, and similar parts	Minus..... 1/4 inch Plus..... 1/2 inch
(d)	Variation in thickness of bridge slabs	Minus..... 1/8 inch Plus..... 1/4 inch
(e)	Footings	
i.	Variation of dimensions in plan	Minus..... 1/2 inch Plus..... 2 inches When formed or plus 3 inches when placed against unformed excavation
ii.	Misplacement of eccentricity	2 percent of the footing width in the direction of misplacement but not more than.....2 inches
iii.	Reduction in thickness	Minus..... .5 percent

1.4.2 Surface Requirements

1.4.2.1 General

The surface requirements for the classes of finish required by paragraph shall be as hereinafter specified. Allowable irregularities are designated "abrupt" or "gradual" for purposes of providing for surface variations. Offsets resulting from displaced, misplaced, or mismatched forms shall be considered "abrupt" irregularities. Irregularities resulting from warping, unplaneness, or similar uniform variations from planeness, or true curvature, shall be considered "gradual" irregularities. "Gradual" irregularities will be checked for compliance with the prescribed limits with a 5-foot template, consisting of a straight edge for plane surfaces and a shaped template for curved or warped surfaces. In measuring irregularities, the straightedge or template may be placed anywhere on the surface in any direction, with the testing edge held parallel to the intended surface.

Class of Finish	Maximum Irregularities Abrupt, Inches	Gradual, Inches
HV	*	1/8
PV	1/8	1/4
Other	1/4	1/2

Class of Finish	Maximum Irregularities Abrupt, Inches	Gradual, Inches
Backfill	1	1

* Variation for Class HV finish shall not exceed zero positive and 1/8-inch negative in the direction of flow of the water.

1.4.2.2 Grinding

Grinding of concrete to meet HV surface requirements is acceptable up to a maximum of 10 exposed aggregate particles with any dimension exceeding 1/4-inch in any 1-square-foot area. The required grinding bevel is as follows:

Station	Bevel (Minimum)
9+10 to 21+02.50	1 to 20

Grinding of surfaces is acceptable up to a maximum of 1/2 inch of removed concrete.

1.4.2.3 Prevention of Repeated Failure to Meet Tolerances

When a concrete placement results in concrete (prior to grinding or patching) that does not meet specified tolerances or surface requirements, an outline of all preventative actions such as modifications to forming, placing, or finishing, to be implemented by the Contractor to avoid repeated failures shall be submitted upon request. The Government reserves the right to delay concrete placements until such approved preventive actions have been implemented.

1.4.3 Appearance

Permanently exposed surfaces shall be cleaned, if stained or otherwise discolored, by a method that does not harm the concrete and that is approved by the Contracting Officer.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Plant Layout, G.

Drawings showing the layout of the plant proposed for use at least 30 days prior to beginning of the plant installation. The drawings shall show the location of the principal components of the construction plant; offices; shop and storage facilities; and storage areas and yards which the Contractor proposes to construct within the project limits. Drawings shall also be furnished showing the general features of the aggregate processing plant; aggregate transporting, storage and reclaiming facilities; coarse aggregate rescreening plant; concrete batching and mixing plant;

concrete conveying and placing plant; and worker's hoists. The drawings shall appropriately show the capacity of each major feature of the plant; rated capacity of the aggregate transporting storage and reclaiming facilities; volume of aggregate stored; capacity of cement storage; rated capacity of the concrete batching and mixing plant; rated capacity of the worker's hoists. The size of the mixers and bins and the structural components of the plant shall also be shown. The layout of other construction facilities shall be provided in sufficient detail to demonstrate adequacy of the facility. The plant layout shall show the proposed location of the laboratory and adjacent parking lot with access roads. Drawings showing any changes in plant made during design and erection or after the plant is in operation shall also be submitted. Final drawings will be submitted in a computerized graphics form satisfactory to the Contracting Officer.

Lift Drawings, G.

A lift drawing and bill of materials shall be furnished for each lift of concrete. (Only one lift shall be shown on a drawing). These drawings shall be to scale and shall show all embedded items in sufficient detail for the proper installation and prosecution of the work. All embedded electrical and/or mechanical items shall be identified. The drawings shall not be less than 22 by 34 inches in size and the scale used shall be sufficiently large to clearly show all details of the structure covered by these drawings. A note shall be included on each lift drawing indicating all contract drawings from which the lift drawing was prepared. The contractor shall submit 6 copies of each drawing for review at least 60 days prior to scheduling the lift for placement. Final drawings will be submitted in a computerized graphics form satisfactory to the Contracting Officer.

SD-03 Product Data

Batch Plant, G.

Details and data on the concrete plant shall be submitted within 60 days prior to assembly for review by the Contracting Officer for review for conformance with the requirements of paragraph: EQUIPMENT.

Mixers

The make, type, capacity, and number of the concrete mixers proposed for use shall be submitted 60 days prior to installation for review by the Contracting Officer for conformance with the requirements of paragraph: EQUIPMENT.

Contractor Supplied Mixture Proportions, G.

Concrete mixture proportions for concrete mixtures as indicated hereinafter to be prepared by the Contractor. The concrete mixture quantities of all ingredients per cubic yard and nominal maximum coarse aggregate size that will be used in the manufacture of each quality of concrete shall be stated. Proportions shall indicate the mass of cement, pozzolan or slag when used and water; the mass of aggregates in a saturated surface-dry condition; and the quantities of admixtures. The submission shall be accompanied

by test reports from a laboratory complying with ASTM C 1077 which show that proportions thus selected will produce concrete of the qualities indicated. No substitution shall be made in the source or type of materials used in the work without additional tests to show that the quality of the new materials and concrete are satisfactory.

Construction Methods; G.

The method, personnel, and equipment proposed for concrete placement of all concrete monoliths 60 days before placement begins. A separate submittal is required for each area, (such as foundation, tower and gates, downstream conduits, and outlet channel. A complete chronological procedure including forms, bulkheads, reinforcement, waterstops, concrete placement, vibration, finishing, joint cleanup, curing, protection, repair of defects, and Contractor quality control shall be included. The plan for placement of concrete in massive elements shall include information as shown in COE EM 1110-2-2000, Chapter 2, Figure 2. The Government reserves the right to delay concrete placements that do not have or are not in accordance with a construction methods as approved by the Contractor Officer.

SD-05 Design Data

Testing Technicians; G.
Concrete Construction Inspector; G.

The Contractor shall submit statements that the concrete testing technicians and the concrete inspectors meet the requirements of paragraph: TESTS AND INSPECTION.

Equipment for Conveying

The methods and description of the equipment proposed for transporting, handling, and depositing the concrete shall be submitted for review 60 days before concrete placement begins. The data submitted shall include site drawings or sketches with locations of equipment and placement site.

Construction Joint Treatment; G.

The method and equipment proposed for joint cleanup and waste disposal shall be submitted for approval for conformance with paragraph: CONSTRUCTION JOINT TREATMENT.

Curing and Protection; G.

The curing media and methods to be used shall be submitted for approval for conformance with paragraph: CURING AND PROTECTION.

Cold Weather Placing; G.

When concrete is to be placed under cold-weather conditions, a description of the materials and methods proposed for protection of the concrete meeting the requirements of paragraph: COLD WEATHER PROTECTION shall be submitted for approval.

Hot-Weather Placing; G.

When concrete is to be placed under hot-weather conditions, a description of the materials and methods proposed for protection of the concrete meeting the requirements of paragraph: HOT-WEATHER PLACING and FINISHING shall be furnished 60 days in advance of anticipated need date for approval.

Special Temperature-Controlled Concrete

When special temperature controls as specified by paragraph: SPECIAL TEMPERATURE-CONTROLLED CONCRETE are required, all methods and equipment shall be submitted for review and comment 60 days in advance of anticipated date required for use.

SD-07 Certificates

Sheet Curing

If sheet curing is used, a manufacturer's certificate shall be furnished certifying that the materials complies with the requirements of ASTM C 171.

Nonshrink Grout; G.

Descriptive literature of the grout proposed for use containing certified laboratory test results showing that it meets ASTM C 1107 shall be submitted 60 days prior to its use together with a certificate from the manufacturer stating that the grout is suitable for the application or exposure for which it is being considered. In addition, a detailed plan shall be submitted for review, showing equipment and procedures for use in mixing and placing the grout.

Bonding Agents

Descriptive literature and certification shall be submitted in advance of their use showing that the following materials meet the specified standards:

Latex Bonding Agent	ASTM C 1059
Epoxy Resin	ASTM C 881 Type V

Expansive Admixture

Manufacturer's descriptive literature for fluidifier to be used as expansive admixture in block-out concrete with certificate stating that the material meets the requirements of ASTM C 937 shall be submitted 60 days prior to its use.

Color Admixture; G

When color-conditioned concrete is specified, color admixture shall be introduced in the concrete. Color sample shall be available with the Contracting Officer, and the color additive shall be submitted for review and approval 60 days prior its use.

Floor and Wall Tiles; G

Sample of tiles and grout shall be submitted to the Contracting

Officer for approval and color selection.

Admixtures; G

Descriptive literature and manufacturer's certificate that the admixture conforms to the requirements of ASTM C 260 or ASTM C 494 as specified hereinafter.

1.6 MATERIAL DELIVERY, STORAGE, AND HANDLING

1.6.1 Cementitious Materials

1.6.1.1 Transportation

When bulk cement, pozzolan, or ground granulated blast-furnace slag is not unloaded from primary carriers directly into weather-tight hoppers at the batching plant, transportation from the railhead, mill, or intermediate storage to the batching plant shall be accomplished in adequately designed weather-tight trucks, conveyors, or other means that will protect the material from exposure to moisture.

1.6.1.2 Storage

Cementitious materials shall be furnished in bulk except that cement used for finishing and patching may be packaged. Immediately upon receipt at the site of the work, all cementitious materials, shall be stored in separate dry, weather-tight, and properly ventilated structures. All storage facilities shall permit easy access for inspection and identification. Sufficient materials shall be in storage to complete any lift of concrete started. In order that cement may not become unduly aged after delivery, the Contractor shall use any cement that has been stored at the site for 60 days or more before using cement of lesser age.

1.6.1.2 Separation of Materials

Separate facilities shall be provided for unloading, transporting, and handling each cementitious material. Separate appropriate storage facilities shall be provided for each type of cement and each source of pozzolan, or slag. The contents of each storage facility shall be plainly marked with a large permanent sign posted near the loading port.

1.6.2 Aggregate Storage

Fine aggregate and each size of coarse aggregate shall be stored in separate size groups adjacent to the batch plant and in such a manner as to prevent the intermingling of size groups or the inclusion of foreign materials in the concrete. Sufficient fine and coarse aggregate shall be maintained at the site at all times to permit continuous placement and completion of any lift of concrete started.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

2.1.1.1 Portland Cement

Portland cement shall conform to ASTM C 150, Type II or V, low-alkali. The Contractor shall submit written certification for the heat of hydration limit as stated herein above for each order of cement delivered to the job at least one day prior to the cement delivered on the job site.

Cement in mixtures for the special temperature control concrete, placed in accordance with the Low Heat Mixtures as described in paragraph Special Temperature-Controlled Concrete shall have the heat of hydration of 70 calories per gram at 7 days.

Cement in mixtures for the special temperature control concrete, placed in accordance with the High Heat Mixtures as described in paragraph Special Temperature-Controlled Concrete need not have the heat of hydration limited to 70 calories per gram at 7 days.

2.1.1.2 Pozzolan

Pozzolan shall conform to ASTM C 618, Class F, with the loss on ignition limited to 6 percent.

2.1.1.3 Ground Granulated Blast-Furnace Slag

Ground granulated blast-furnace slag shall conform to ASTM C 989, Grade 120.

2.1.1.4 Portland Cement for use with the Ground Granulated Blast-Furnace Slag Concrete Mixtures

For those mixtures prepared by the Government, the contractor may be allowed to use an ASTM C 150 Type II, low alkali cement, without the heat of hydration limited to 70 calories per gram at 7 days.

2.1.1.5 Temperature of Cementitious Materials

The temperature of the cementitious materials as delivered to the site shall not exceed 150 degrees F.

2.1.2 Admixtures

All chemical admixtures furnished as liquids shall be in a solution of suitable viscosity for field use as determined by the Contracting Officer.

2.1.2.1 Accelerating Admixture

Calcium chloride shall not be used. Accelerators shall meet the requirements of ASTM C 494, Type C.

2.1.2.2 Retarding Admixture

A retarding admixture shall meet the requirements of ASTM C 494, Type B, or D, except that the 6-month and 1-year compressive strength tests are waived. The admixture may be added to the concrete mixture only when approved.

2.1.2.3 Water-Reducing Admixture

Water-reducing admixtures shall conform to ASTM C 494, Type A.

2.1.2.4 Expansive Admixture

Expansive admixture used in block-out concrete shall conform to ASTM C 937.

2.1.2.5 Color Admixture

Color admixture for color-conditioned concrete shall match the color sample available from the Contracting Officer.

2.1.2.6 Air-Entraining Admixture

Air Entraining admixture shall conform to ASTM C 260 and shall consistently entrain the air content in the specified ranges under field conditions.

2.1.3 Curing Materials

2.1.3.1 Sheet Materials

Sheet curing materials shall conform to ASTM C 171, type optional, except polyethylene sheet shall not be used.

2.1.3.2 Membrane-Forming Curing Compound

Membrane-forming curing compound shall conform to ASTM C 309, Type 2, except a styrene acrylate or chlorinated rubber compound meeting ASTM C 309, Class B, requirements may be used for surfaces that are to be painted or are to receive subsequent coatings, or floors that are to receive adhesive applications of resilient flooring. The curing compound selected shall be compatible with any subsequent paint, roofing, coating, or flooring specified.

2.1.3.3 Burlap

Burlap for curing purposes shall conform to COE CRD-C 318.

2.1.4 Water

Water for washing aggregates and for mixing and curing concrete shall be free from injurious amounts of oil, acid, salt, alkali, organic matter, or other deleterious substances and shall comply with COE CRD-C 400.

2.1.5 Aggregates

2.1.5.1 Aggregate Composition

Fine aggregate shall consist of natural sand, manufactured sand, or a combination of natural and manufactured sands. Coarse aggregate shall consist of gravel, crushed gravel, crushed stone, or a combination thereof.

2.1.5.2 Quality

Aggregates delivered to the mixer shall be obtained from the specified sources and shall conform to the requirements of ASTM C 33.

2.1.5.3 Grading

a. Fine Aggregate - The grading of the fine aggregate as delivered to the mixers shall be such that the individual percent retained on any sieve shall not vary more than 3 percent from the percent retained on that sieve in a fixed grading selected by the Contractor with the approval of the Contracting Officer. The

fixed grading may be selected at the start of concrete placement and based upon 30 days fine aggregate production or selected after the first 30 days of concrete placement. The minimum individual percent retained on the No. 8 sieve shall be 5 percent and on all smaller sieves shall be 10 percent. In addition to the grading limits, the fine aggregate, as delivered to the mixer, shall have a fineness modulus of not less than 2.25 nor more than 2.85. The grading of the fine aggregate shall also be controlled so that the fineness moduli groups (average of the current test and the previous two tests) of the fine aggregate as delivered to the mixer shall not vary more than 0.10 from the target fineness modulus of the fixed grading selected by the Contractor and approved by the Contracting Officer. The range of each group shall not exceed 0.20. The fineness modulus shall be determined in accordance with COE CRD-C 104. At the option of the Contractor, fine aggregate may be separated into two or more sizes or classifications, but the uniformity of grading of the separate sizes shall be controlled so that they may be combined throughout the job in fixed proportions established during the first 30 days of concrete placement. The selected fixed grading shall be within the following limits, except any individual test result may be outside these limits if within the allowable 3 percent variation from the selected grading.

U.S. STANDARD SIEVE DESIGNATION	PERMISSIBLE LIMITS PERCENT BY WEIGHT, PASSING
3/8-in.	100
No. 4	95 - 100
No. 8	80 - 95
No. 16	60 - 80
No. 30	35 - 60
No. 50	15 - 30
No. 100	5 - 10
No. 200	0 - 5

b. Coarse Aggregate - The coarse aggregate shall be rescreened just prior to delivery to the concrete batch plant bins. The grading of the coarse aggregate within the separate size groups shall conform to the following requirements as delivered to the mixer.

PERCENT BY WEIGHT PASSING INDIVIDUAL SIEVES

U.S. STANDARD SIEVE DESIGNATION	No.4 to 3/4 inch	3/4 inch to 1-1/2 inch
2 inch	-	100
1-1/2 inch	-	90 - 100
1 inch	100	20 - 45
3/4 inch	90 - 100	0 - 10
3/8 inch	20 - 55	0 - 5
No. 4	0 - 10	
No. 8	0 - 5	

2.1.5.4 Particle Shape

The quantity of flat and elongated particles in the separate size groups of coarse aggregate, as determined by ASTM D 4791, using a value of 3 for

width-thickness ratio and length-width ratio shall not exceed 25 percent in any size group.

2.1.5.5 Moisture Content

The fine aggregate shall not be placed in bins at the batch plant until it is in a stable state of moisture content. A stable moisture content shall be reached when the variation in the percent of total moisture tested in accordance with ASTM C 566 and when sampled at the same location will not be more than 0.5 percent during 1 hour of the 2 hours prior to placing the material in the batch plant bins and the variation in moisture content when sampled at the same location shall not be more than 2.0 percent during the last 8 hour period that the aggregate remains in the stockpile. The coarse aggregate shall be delivered to the mixers with the least amount of free moisture and the least variation in free moisture practicable under the job conditions. Under no conditions shall the coarse aggregate be delivered to the mixer "dripping wet".

2.1.5.6 Commercial Concrete Aggregate Sources

Concrete aggregates may be furnished from any source capable of meeting the quality requirements stated in paragraph: AGGREGATES. The following sources were evaluated during the design phase of the project in 1995 and were found at that time capable of meeting the quality requirements when suitably processed. No guarantee is given or implied that any of the following listed sources are currently capable of producing aggregates that meet the required quality stated in paragraph: AGGREGATES. Test results and conclusions shall be considered valid only for the sample tested and shall not be taken as an indication of the quality of all material from a source nor for the amount of processing required.

a. List of Sources:

   Robertsons Redimix, Gypsum Canyon
   Sunwest Materials, Lytle Creek
   Inland Rock Co., Day Creek

b. Selection of Source - After the award of the contract, the Contractor shall designate in writing only one source or combination of sources from which he proposes to furnish aggregates. Regardless of the source selected, samples for quality-assurance testing shall be provided as required by paragraph: PRECONSTRUCTION TESTING AND MIXTURE-PROPORTIONING STUDIES. If a source for coarse or fine aggregate so designated by the Contractor does not meet the quality requirements stated in the paragraph: AGGREGATE, the Contractor may not submit for approval other sources but shall furnish the coarse or fine aggregate, as the case may be, from one or a combination of the sources listed at no additional cost to the Government.

2.1.6 Nonshrink Grout

Nonshrink grout for use in setting base plates and machinery shall conform to ASTM C 1107, and shall be a commercial formulation suitable for the application proposed. The Grade of grout shall be as indicated by the manufacturer, for the particular application selected.

2.1.7 Packaged Dry Repair Materials

Packaged dry rapid-hardening cementitious materials for concrete repairs shall be a commercial formulation conforming to ASTM C 928 requiring only the addition of water.

2.1.8 Bonding Agents

Bonding agents shall meet the following requirements.

2.1.8.1 Latex Bonding Agent

Latex agents for bonding fresh to hardened concrete shall conform to ASTM C 1059, Type II.

2.1.8.2 Epoxy Resin

Epoxy resins for use in repairs, epoxy grout, and grouting dowels shall conform to ASTM C 881, Type V, Grade I or II.

2.1.9 Surface Retarder

Surface retarder shall conform to COE CRD-C 94.

2.1.10 Floor and Wall Tiles

Tiles for floor and walls in the toilet room shall be 1" x 1" x 3/8" and shall be standard grade glazed tiles conforming to ANSI A137.1. Specially shaped tiles shall be provided as required at corners, edges, etc.

2.2 MIXTURE PROPORTIONING

2.2.1 Composition

Concrete shall be composed of cementitious materials, water, fine and coarse aggregates, and admixtures. The cementitious materials shall be portland cement, portland cement in combination with pozzolan, or portland cement in combination with ground granulated blast-furnace slag. The admixtures shall be an Air Entraining Admixture, an WRA or an accelerating admixture. A retarding admixture may be used at the request of the Contractor when approved. No other chemical admixtures than those listed above shall be used. For each portion of the structure, mixture proportions shall be selected so that the strength and W/C requirements listed in paragraph: DESIGN REQUIREMENTS are met.

2.2.2 Proportioning Responsibility

The concrete mixtures in the intake structure, below elevation 500 and the stilling basin invert will be proportioned by the Contracting Officer. All other mixtures will be proportioned by the Contractor. Preliminary mixture-proportioning studies or thermal studies which include mixture proportions are available for review in the District Office. Some mixtures, especially those containing higher amounts of pozzolans, may have slow strength gain which may impact form design and form removal time.

2.2.3 Government-Designed Mixtures

Based on preliminary mix design studies the Government-designed mixtures for use in the mass concrete construction will contain the following approximate amounts of cementitious materials. Final mix designs will be determined using the proposed job materials in accordance with paragraph:

Materials for Mixture Proportioning Studies.

2.2.3.1 Mixtures Using Type V and/or Type II Cement in Combination with Fly Ash

Mixtures containing Type V and/or Type II cement shall contain approximately 320 lbs of cement and 140 lbs of fly ash per cubic yard.

2.2.3.2 Mixtures Using Type II Cement in Combination with Granulated Ground Blast Furnace Slag (GGBFS) Cement

Mixtures containing Type II cement in combination with GGBFS shall contain approximately 150 lbs of Type II cement and 320 lbs of GGBFS cement per cubic yard.

2.2.4 Control

The proportions of all material entering into each concrete mixture will be furnished to the Contractor. The proportions will be changed by the Contracting Officer as necessary. Adjustments shall be made by the Contractor to the batch weights of aggregates and water as necessary to compensate for free moisture in the aggregates.

2.2.5 Nominal Maximum-Size of Aggregate

The nominal maximum-size of coarse aggregate to be used in the various parts of the work shall be in accordance with the following tabulation except as directed. The NMSA may be changed for sections requiring a special quality of concrete as directed.

FEATURES	NOMINAL MAXIMUM-SIZE AGGREGATE
Sections 7-1/2 in. or less in width or slabs 4 in. or less in thickness or any section with a clear distance between reinforcement less than 2-1/4 in.	3/4 in.
Sections over 7-1/2 in. or slabs at least 4 in. in thickness. However, this size shall not be used in any section in which the clear distance between reinforcement is less than 2-1/4 in.	1-1/2 in.

2.2.6 Slump

The slump shall be determined in accordance with ASTM C 143 and shall be 2 inches + 1 inch for massive features and between 1 and 4 inches for all others except where placement by pump is approved, in which case the slump shall be 4-1/2 + 1-1/2 inches. In addition, the range of each set of two consecutive tests for each mixture shall be not more than 2 inches. The above specified slump is that required at the forms.

2.2.7 Air Content

The air content by volume shall be determined in accordance with ASTM C 143. When the nominal maximum size of coarse aggregate is 1-1/2 inches or larger, the total air content of the sample measured in accordance with ASTM C 231 shall be between 4 and 7 percent. When the nominal maximum-size

coarse aggregate is 3/4 inch, the air content shall be between 5 and 7 percent. The specified air content is that required at the forms.

2.2.8 Contractor Concrete Proportioning

Trial batches and testing requirements for various qualities of concrete specified shall be the responsibility of the Contractor. Samples of aggregates shall be obtained in accordance with the requirements of ASTM D 75. Samples of materials other than aggregate shall be representative of those proposed for the project and shall be accompanied by the manufacturer's test reports indicating compliance with applicable specified requirements. Trial mixtures having proportions, consistencies, and air content suitable for the work shall be made based on methodology described in ACI 211.1, using at least three different water-cement ratios, which will produce a range of strength encompassing those required for the work. The maximum water-cement ratios required in paragraph: MAXIMUM WATER-CEMENT RATIO will be converted to a weight ratio of water to cement plus pozzolan by mass, or GGBF slag by mass equivalency as described in ACI 211.1. In the case where GGBF slag is used, the weight of the slag shall be included in the equations for the term P, which is used to denote the mass of pozzolan. If pozzolan is used in the concrete mixture, the minimum pozzolan content shall be 15 percent of the total cementitious material. Trial mixtures shall be proportioned for maximum permitted slump and air content with due consideration to the approved conveying and placement method. The temperature of concrete in each trial batch shall be reported. For each water-cement ratio, at least three test cylinders for each test age shall be made and cured in accordance with ASTM C 192. They shall be tested at 7 days and at the design age specified in paragraph: DESIGN REQUIREMENTS in accordance with ASTM C 39. From these test results, a curve will be plotted showing the relationship between water-cement ratio and strength.

2.2.9 Required Average Compressive Strength

In meeting the strength requirements specified in paragraph: CONCRETE STRENGTH, the selected mixture proportion shall produce a required average compressive strength f'cr exceeding the specified strength f'c by the amount indicated below.

2.2.9.1 Average Compressive Strength from Test Records

Where a concrete production facility has test records, a standard deviation shall be established in accordance with the applicable provisions of ACI 214. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected, shall represent concrete produced to meet a specified strength or strengths (f'c) within 1,000 psi of that specified for proposed work, and shall consist of at least 30 consecutive tests. A strength test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days or at another test age designated for determination of f'c. Required average compressive strength f'cr used as the basis for selection of concrete proportions shall be the larger of the equations that follow using the standard deviation as determined above:

$$f'cr = f'c + 1.34S$$
$$f'cr = f'c + 2.33S - 500$$

Where S = standard deviation

Where a concrete production facility does not have test records meeting the

requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation shall be established as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS*	MODIFICATION FACTOR FOR STANDARD DEVIATION
less than 15	-**
15	1.16
20	1.08
25	1.03
30 or more	1.00

* Interpolate for intermediate numbers of tests.
** Use tabulation in paragraph: DETERMINING REQUIRED AVERAGE STRENGTH

2.2.9.2 Average Compressive Strength without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required average strength fcr shall be determined as follows: If the specified compressive strength f'c is less than 3,000 psi,

f'cr = f'c + 1,000

If the specified compressive strength f'c is 3,000 to 5,000 psi,

f'cr = f'c + 1,200

If the specified compressive strength f'c is over 5,000 psi,

f'cr = f'c + 1,400

2.2.10 Color-Conditioned Concrete

The dosage rate of the color admixture used shall be as specified by the manufacturer. The proportions of the other admixtures used shall be adjusted as required to provide a workable concrete mix. A vertical sample panel of adequate size shall be made for approval using the contemplated materials and construction techniques.

PART 3 EXECUTION

3.1 EQUIPMENT

3.1.1 Capacity

The batching, mixing, conveying, and placing systems shall have a capacity of at least 100 cubic yards per hour.

3.1.2 Batch Plant

Batch plant shall meet the following requirements.

3.1.2.1 Location

The concrete production plant shall be located at the site of the work in a specific location selected by the Contractor.

3.1.2.2 Bins and Silos

Separate bins, compartments, or silos shall be provided for each size or classification of aggregate and for each of the cementitious materials. The compartments shall be of ample size and so constructed that the various materials will be maintained separately under all working conditions. All compartments containing bulk cement, pozzolan, or ground granulated blast-furnace slag shall be separated from each other by a free-draining air space. All filling ports shall be clearly marked with a permanent sign stating the contents.

3.1.2.3 Batching Equipment

a. Batchers - Aggregate shall be weighed in separate weigh batchers with individual scales. Bulk cement and/or other cementitious materials shall each be weighed on a separate scale in a separate weigh batcher. Water shall be measured by weight or by volume. If measured by weight, it shall not be weighed cumulatively with another ingredient. Ice shall be measured separately by weight. Admixtures shall be batched separately and shall be batched by weight or by volume in accordance with the manufacturer's recommendations.

b. Water Batcher - A suitable water-measuring and batching device shall be provided that will be capable of measuring and batching the mixing water within the specified tolerances for each batch. The mechanism for delivering water to the mixers shall be free from leakage when the valves are closed. The filling and discharge valves for the water batcher shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. When a water meter is used, a suitable strainer shall be provided ahead of the metering device.

c. Admixture Dispensers - A separate batcher or dispenser shall be provided for each admixture. Each plant shall be equipped with the necessary calibration devices that will permit convenient checking of the accuracy of the dispensed volume of the particular admixture. The batching or dispensing devices shall be capable of repetitively controlling the batching of the admixtures to the accuracy specified. Piping for liquid admixtures shall be free from leaks and properly valved to prevent backflow or siphoning. The dispensing system shall include a device or devices that will detect and indicate the presence or absence of the admixture or provide a convenient means of visually observing the admixture in the process of being batched or discharged. Each system shall be capable of ready adjustment to permit varying the quantity of admixture to be batched. Each dispenser shall be interlocked with the batching and discharge operations so that each admixture is added separately to the batch in solution in a separate portion of the mixing water or in fine aggregate in a manner to ensure uniform distribution of the admixtures throughout the batch during the required mixing period. Storage and handling of admixtures shall be in accordance with the manufacturers recommendations.

d. Moisture Control - The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the weights of the materials being batched. A moisture meter complying with the provisions of COE CRD-C 143 shall be provided for measurement of moisture in the fine

aggregate. The sensing element shall be arranged so that the measurement is made near the batcher charging gate of the fine aggregate bin or in the fine aggregate batcher.

e. Scales - Adequate facilities shall be provided for the accurate measurement and control of each of the materials entering each batch of concrete. The weighing equipment and controls shall conform to the applicable requirements of NIST HB 44, except that the accuracy shall be within 0.2 percent of the scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Tests shall be made at the frequency required in paragraph: TESTS AND INSPECTIONS, and in the presence of a Government quality assurance representative. Each weighing unit shall include a visible indicator that shall indicate the scale load at all stages of the weighing operation and shall show the scale in balance at zero load. The weighing equipment shall be arranged so that the concrete plant operator can conveniently observe the indicators.

f. Operation and Accuracy - The weighing operation of each material shall start automatically when actuated by one or more starter switches and shall end when the designated amount of each material has been reached. These requirements can be met by providing a semiautomatic or automatic batching system as defined by NRMCA CPMB 100. There shall be equipment to permit the selection of 5 preset mixes each by the movement of not more than two switches or other control devices. Cumulative weighing will not be permitted. The weigh batchers shall be so constructed and arranged that the sequence and timing of batcher discharge gates can be controlled to produce a ribboning and mixing of the aggregates, water, admixtures, and cementitious materials as the materials pass through the charging hopper into the mixer. The plant shall include provisions to facilitate the inspection of all operations at all times. Delivery of materials from the batching equipment shall be within the following limits of accuracy:

MATERIAL	PERCENT
Cementitious materials	+ 1
Water	+ 1
Aggregate smaller than 1-1/2 in. size	+ 2
Aggregate larger than 1-1/2 in. size	+ 3
Chemical admixtures	+ 3

g. Interlocks - Batchers and mixers shall be interlocked so that:

(1) The charging device of each batcher cannot be actuated until all scales have returned to zero balance within + 0.2 percent of the scale capacity and each volumetric device has reset to start or has signaled empty.

(2) The charging device of each batcher cannot be actuated if the discharge device is open.

(3) The discharge device of each batcher cannot be actuated if the charging device is open.

(4) The discharge device of each batcher cannot be actuated until the indicated material is within the allowable tolerances.

(5) One admixture is batched automatically with the water.

(6) Each additional admixture is batched automatically with a separate portion of the water or with the fine aggregate.

(7) The mixers cannot be discharged until the required mixing time has elapsed.

h. Recorder - An accurate recorder or recorders shall be provided and shall conform to the following detailed requirements:

(1) The recorder shall produce a graphical or digital record on a single visible chart or tape of the weight or volume of each material in the batchers at the conclusion of the batching cycle. The record shall be produced prior to delivery of the materials to the mixer. After the batchers have been discharged, the recorder shall show the return to empty condition.

(2) A graphical recording or digital printout unit shall be completely housed in a single cabinet that shall be capable of being locked.

(3) The chart or tape shall be so marked that each batch may be permanently identified and so that variations in batch weights of each type of batch can be readily observed. The chart or tape shall be easily interpreted in increments not exceeding 0.5 percent of each batch weight.

(4) The chart or tape shall show time of day at intervals of not more than 15 minutes.

(5) The recorder chart or tape shall become the property of the Government.

(6) The recorder shall be placed in a position convenient for observation by the concrete plant operator and the Government inspector.

(7) The recorded weights or volumes when compared to the weights or volumes actually batched shall be accurate within + 2 percent.

i. Batch Counters - The plant shall include devices for automatically counting the total number of batches of all concrete batched and the number of batches of each preset mixture.

j. Rescreening Plant - A rescreening plant shall be located, arranged, and operated in a manner that all coarse aggregate will be routed through the plant and that its operation will ensure delivery to the mixers of graded coarse aggregate free from excessive variation and conforming to the size groups and grading

of paragraph: AGGREGATES and with moisture content conforming to the provisions of paragraph: MOISTURE CONTENT. Coarse aggregate may be rescreened and delivered to the batch plant bins one size group at a time or two or more adjacent size groups at a time. Simultaneous rescreening of nonadjacent size groups is not permitted. All material passing the bottom screen of the smallest size of coarse aggregate being screened shall be wasted.

k. Washing Plant - All coarse aggregates shall be washed immediately prior to entering the rescreening plant. The rewashing plant shall contain adequate water nozzles and vibrating screens to remove foreign materials and coatings from aggregate particles. Water used for washing shall meet the requirements of paragraph: WATER.

l. Trial Operation - Not less than 7 days prior to commencement of concrete placing, a test of the batching and mixing plant shall be made in the presence of the Contracting Officer to check operational adequacy. The number of full-scale concrete batches required to be produced in trial runs shall be as directed, will not exceed 20, and shall be proportioned as directed. All concrete produced in these tests shall be wasted or used for purposes other than inclusion in structures covered by this specification. All deficiencies found in plant operation shall be corrected prior to the start of concrete placing operations. No separate payment will be made to the Contractor for labor or materials required by provisions of this paragraph. The Contractor shall notify the Contracting Officer of the trial operation not less than 7 days prior to the start of the trial operation.

m. Protection - The weighing, indicating, recording, and control equipment shall be protected against exposure to dust, moisture, and vibration so that there is no interference with proper operation of the equipment.

3.1.2.4 Laboratory Areas

A room shall be provided in the plant to house the moisture and grading testing equipment for aggregate and to provide working space. Another room shall be provided for testing fresh concrete and for fabricating and initial curing of concrete test specimens in accordance with ASTM C 31. The size, arrangement, and location of these rooms will be subject to approval. The Contractor shall provide electricity, air conditioning, heat, and water as required for use in these laboratory areas. Section 01500 Quality Assurance of these specifications presents requirements for a separate building equipped for a testing laboratory.

3.1.2.5 Plant Layout Drawings

Drawings, in triplicate, showing the layout of the plant the Contractor proposes to use on the work shall be submitted by the Contractor for review. The drawings shall show the locations of the principal components of the construction plant; offices; shop and storage building; housing facilities, if any; and storage areas and yards which the Contractor proposes to construct at the site of the work and elsewhere. The Contractor shall also furnish for review drawings, in triplicate, showing the general features of his aggregate processing plant; aggregate transporting; storage and reclaiming facilities; aggregate rinsing and

dewatering plant, if required; coarse aggregate rescreening plant, if required; concrete batching and mixing plant; concrete conveying and placing plant; and when precooling of concrete is required, the cooling plant. The drawing shall appropriately show the capacity of each major feature of the plant including the rated capacity of the aggregate production plant in tons per hour of fine and coarse aggregates; rated capacity of the aggregate transporting, storage and reclaiming facilities; volume of aggregate storage; capacity of cement and pozzolan storage; rated capacity of the concrete batching and mixing plant in cubic yards per hour; rated capacity of the concrete transporting and placing plant in cubic yards per hour; and when used rated capacity of plant for precooling of concrete. Drawings in triplicate showing any changes in plant made during design and erection or after the plant is in operation shall be submitted for review. Two sets of the drawings will be retained and one set will be returned to the Contractor with comments. Final drawings incorporating final comments and any changes made during operation of the plants will be supplied to the Government on drawings in an electronic media format acceptable to the Contracting Officer.

3.1.3 Mixers

Mixers shall be stationary mixers. Each mixer shall combine the materials into a uniform mixture and discharge this mixture without segregation. Mixers shall not be charged in excess of the capacity recommended by the manufacturer on the nameplate. Excessive over-mixing requiring introduction of additional water will not be permitted. The mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free of hardened concrete. Mixer blades or paddles shall be replaced when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired or replaced. The size of the batch, the mixing time, the charging sequence, and other factors identified by the contractor shall be adjusted to provide concrete that meets the uniformity limits specified herein. All testing shall be performed in accordance with COE CRD-C 55. When regular testing is performed, the concrete shall meet the limits of any five of the six uniformity requirements. When abbreviated testing is performed, the concrete shall meet only those requirements listed for abbreviated testing. The initial mixer evaluation test shall be a regular test and shall be performed prior to the start of concrete placement. The concrete proportions used for the evaluation shall contain the largest size aggregate on the project and shall be as directed. Regular testing shall consist of performing all six tests on three batches of concrete. The range for regular testing shall be the average of the ranges of the three batches. Abbreviated testing shall consist of performing the three required tests on a single batch of concrete. The range for abbreviated testing shall be the range for one batch. If more than one mixer is used and all are identical in terms of make, type, capacity, condition, speed of rotation, etc., the results of tests on one of the mixers shall apply to the others, subject to approval. Mixer evaluations shall be performed by the Contractor in accordance with paragraph: MIXER UNIFORMITY. However, the initial evaluation will be performed by the Government. The Contractor shall provide labor and equipment as directed to assist the Government in performing any evaluation made by the Government.

PARAMETER	REGULAR TESTS ALLOWABLE MAXIMUM RANGE FOR AVERAGE OF 3 BATCHES	ABBREVIATED TESTS ALLOWABLE MAXIMUM RANGE FOR 1 BATCH
Unit weight of air-free mortar, lb/cu ft	2.0	2.0
Air content, percent	1.0	---
Slump, inches	1.0	---
Coarse aggregate, percent	6.0	6.0
Compressive strength at 7 days, percent	10.0	10.0
Water content, percent	1.5	---

3.1.4 Sampling Facilities

3.1.4.1 Concrete

The Contractor shall provide suitable facilities and labor for obtaining representative samples of concrete in accordance with ASTM C 172 for Contractor quality control (QC) and Government quality assurance (QA) testing.

3.1.4.2 Coarse Aggregate

Suitable facilities shall be provided for readily obtaining representative samples of coarse aggregate for test purposes immediately prior to the material entering the mixer.

3.1.5 Transporting Equipment

Transporting equipment shall be designed, operated, and maintained so that it does not cause or permit segregation or loss of material. The concrete shall not be dropped vertically more than 5 feet except where suitable equipment is provided to prevent segregation and where specifically authorized.

3.1.5.1 Buckets

Bottom-dump buckets shall conform to the following requirements: the interior hopper slope shall be not less than 70 degrees from the horizontal; the minimum dimension of the clear gate opening shall be at least five times the nominal maximum size of the aggregate, and the area of the gate opening shall not be less than 2 square feet; the bucket gates shall be grout-tight when closed, shall be of the double clamshell type, and shall be manually, pneumatically, or hydraulically operated; and the gate-opening mechanism shall be designed to close the gates automatically when the control is released or when the air or hydraulic line is broken. If gate actuation is dependent on integral air or hydraulic reservoirs, the capacity of the reservoirs shall be sufficient to open and close the gates three times without recharging the reservoir.

3.1.5.2 Trucks

Truck mixers or agitators used for transporting central-mixed concrete shall conform to the applicable requirements of ASTM C 94. Truck mixers shall not be used to transport concrete with larger than 1-1/2 inch nominal maximum-size aggregate or 2 inch or lower slump. Nonagitating trucks may be used for transporting central-mixed concrete over a smooth road when the hauling time is less than 15 minutes and the slump is less than 3 inches. Bodies of nonagitating trucks shall be smooth, watertight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation, and equipped with gates that will permit positive control of the discharge of the concrete.

3.1.5.3 Chutes

When concrete can be placed directly from a truck mixer, agitator, or nonagitating truck, the chutes supplied by the truck manufacturer as standard equipment may be used. A discharge deflector shall be used when required by the Contracting Officer. Separate chutes and other similar equipment shall not be permitted for conveying concrete except when specifically approved and in no case shall slump be increased to accommodate their use.

3.1.5.4 Belt Conveyors

Belt conveyors shall be designed and operated to assure a uniform flow of concrete from mixer or delivery truck to final place of deposit without segregation of ingredients or loss of mortar and shall be provided with positive means for preventing segregation of the concrete or loss of mortar at the transfer point(s) and the point of placing. The idler spacing shall not exceed 36 inches. Belt speed shall be a minimum of 300 feet per minute and a maximum of 750 feet per minute. Belt width shall be a minimum of 16 inches if the NMSA is 3 inches or less. The NMSA required in mixture proportions furnished by the Government will not be changed to accommodate the belt width.

3.1.5.5 Pump Placement

Concrete may be conveyed by positive-displacement pump when approved. Pump placement will be approved only for areas where placement by bucket or conveyor is difficult or impractical. The pumping equipment shall be piston or squeeze-pressure type. The pipeline shall be rigid-steel pipe or heavy-duty flexible hose. Aluminum pipe shall not be used. The inside diameter of the pipe shall be at least 3 times the nominal maximum size of the coarse aggregate in the concrete to be pumped but not less than 4 inches.

3.2 PREPARATION FOR PLACING

3.2.1 Vibrators

An adequate number of vibrators shall be on hand to meet placing requirements, and spare vibrators shall be available to maintain production in the event of breakdown. There shall be adequate air pressure available for air vibrators and adequate voltage for electric vibrators. Vibrators of the proper size, frequency, and amplitude shall be used for the type of work being performed in conformance with the following requirements:

APPLICATION	HEAD DIAMETER INCHES	FREQUENCY VPM	AMPLITUDE INCHES
Thin walls, beams, etc.	1-1/4 - 2-1/2	9,000 - 13,500	0.020 - 0.04
General construction	2 - 3-1/2	8,000 - 12,000	0.025 - 0.05
Heavy sections	3 - 6	7,000 - 10,500	0.030 - 0.06
Mass concrete	5 - 7	5,500 - 8,500	0.040 - 0.08

The frequency and amplitude shall be within the range indicated in the tabulation as determined in accordance with paragraph: TESTS AND INSPECTIONS.

3.2.2 Embedded Items

Before placing concrete, care shall be taken to determine that all embedded items are securely fastened in place as indicated in the drawings or required. Embedded items shall be free of oil and other foreign matter such as loose coatings of rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Any air or water lines or other materials embedded in structures as authorized construction expedients shall conform to the above requirements and upon completion of their use shall be backfilled with concrete or mortar as directed. Welding will not be permitted on embedded or otherwise exposed metals which are in contact with concrete surfaces. Tack welding of or to embedded items will not be permitted.

3.2.3 Concrete on Earth Foundations

Earth foundations upon which concrete is to be placed shall be clean, damp, and free from frost, ice, and standing or running water. Prior to placement of concrete, the earth foundation shall have been satisfactorily compacted in accordance with the provisions of Sections 02212 Embankment or 02250 Fills and Subgrade Preparation, as applicable.

3.2.4 Concrete on Rock Foundations

Rock surfaces upon which concrete is to be placed shall be clean and free from oil, standing or running water, ice, mud, drummy rock, coatings, debris, and loose, semidetached, overhanging, or unsound fragments. Faults or joints shall be cleaned to a satisfactory depth and to firm rock on the sides as directed by the Contracting Officer. Immediately before concrete is placed, all rock surfaces shall be cleaned thoroughly by the use of air-water jet, high-pressure water jet, or sandblasting as described in paragraph: CONSTRUCTION JOINT TREATMENT. All rock surfaces shall be kept continuously wet for at least 24 hours immediately prior to placing concrete thereon. All approximately horizontal surfaces shall be covered immediately before the concrete is placed with a 1/2 inch layer of mortar composed of the same sand and cementitious materials used in the concrete. The sand-cementitious materials ratio and the water-cementitious material ratio of the mortar shall be approximately the same as those used in the concrete mixture. The mortar shall be covered with concrete before the mortar has reached its initial time of setting.

3.2.5 Construction Joint Treatment

3.2.5.1 Joint Preparation

Concrete surfaces to which other concrete is to be bonded shall be prepared

for receiving the next lift or adjacent concrete by cleaning by sandblasting, high-pressure water jet, or air-water cutting. Surface cutting by air-water jets will not be permitted for concrete surfaces congested with reinforcing steel or if they are relatively inaccessible. If, for any other reason, it is considered undesirable to disturb the surface of a lift before it has hardened, the use of sandblasting or high-pressure water jet after hardening will be required. Regardless of the method used, the resulting surface shall be free from all laitance and inferior concrete so that clean, well-bonded coarse aggregate particles are exposed uniformly over the lift surface. Application of the joint treatment method shall be such that the edges of the larger particles of aggregate are not undercut. Where joint preparation occurs more than 2 days prior to placing the next lift or where the work in the area subsequent to the joint preparation causes dirt or debris to be deposited on the surface, the surface shall be cleaned as the last operation prior to placing the next lift. The surface of the construction joint shall be kept continuously wet for the first 12 hours of the 24 hours prior to placing concrete, except that the surface shall be damp with no free water at the time of placement.

3.2.5.2 Air-Water Cutting

Air-water cutting of a construction joint shall be performed at the proper time, generally between 4 and 12 hours after placement and only on horizontal construction joints. This period may be modified if a retarder is used to prolong the setting of the cement at surface of the concrete. The air pressure used in the jet shall be 90 to 110 psi, and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. When approved a surface retarder complying with the requirements of COE CRD-C 94 may be applied to the surface of the lift to prolong the period of time during which air-water cutting is effective. Prior to receiving approval, the Contractor shall furnish samples of the material to be used and shall demonstrate the method to be used in its application. After cutting, the surface shall be washed and rinsed until the wash water is no longer cloudy. If air-water cutting does not produce acceptable results, the surface shall be prepared by high-pressure water jet or sandblasting.

3.2.5.3 High-Pressure Water Jet

A stream of water under a pressure of not less than 3,000 psi may be used for cleaning. Its use shall be delayed until the concrete is sufficiently hard so that only the surface skin or mortar is removed and there is no undercutting of coarse-aggregate particles. If the high-pressure water jet is incapable of a satisfactory cleaning, the surface shall be cleaned by sandblasting.

3.2.5.4 Wet Sandblasting

This method of joint preparation may be used when the concrete has reached sufficient strength to prevent undercutting of coarse aggregate particles. The operation shall be continued until all accumulated laitance, coatings, stains, debris, and foreign materials are removed. The surface of the concrete shall then be washed thoroughly to remove all loose material. This method may be used on both horizontal and vertical surfaces.

3.2.5.5 Waste Water Disposal

The method used in disposing of waste water employed in cutting, washing,

and rinsing of concrete surfaces shall be such that the waste water does not stain, discolor, or affect exposed surfaces of the structures, or damage the environment of the project area. The method of disposal shall meet all requirements of Section 01430 Environmental Protection.

3.3 TRANSPORTING AND PLACING

3.3.1 Transporting

Methods and equipment for conveying and depositing the concrete into the form shall be subject to approval. The capacity of the transporting system shall be sufficient to supply concrete at a rate to prevent cold joints forming during placement. A properly designed and sized elephant trunk and rigid drop chute bottom section which will prevent free-fall within the elephant trunk and rigid drop chute will be used if concrete is to drop more than 5 feet. If concrete is to be placed through installed horizontal or sloping reinforcing bars, the concrete shall discharge into a pipe or elephant trunk that is long enough to extend through the reinforcing bars to within 5 feet of the placing surface. In no case will concrete be discharged to free fall through the reinforcing bars.

3.3.1.1 Transporting by Bucket

There shall be provided indicating and signaling devices for the control of identification of types or classes of concrete as they are mixed and discharged into buckets for transfer to the forms. Each type or class of concrete shall be visually identified by placing a colored tag or marker on a bucket as it leaves the mixing plant so that the concrete may be positively identified in the forms and placed in the structure in the desired position.

3.3.1.2 Transporting by Pump

The nominal maximum-size coarse aggregate will not be reduced or mixture proportions changed to accommodate a pump except as specifically determined appropriate. The distance and height to be pumped shall not exceed limits recommended by the pump manufacturer. The concrete shall be supplied to the pump continuously. When pumping is completed, concrete remaining in the pipeline shall be ejected without contamination of concrete in place. After each operation the equipment shall be thoroughly cleaned and flushing water shall be wasted outside the forms.

3.3.1.3 Transporting by Belt Conveyor

Methods and equipment for transporting the concrete by belt conveyor into the form shall be subject to approval.

3.3.2 Placing

The capacity of the placing system shall be sufficient to supply concrete at a rate which will prevent cold joints in any placement. Concrete shall be worked into the corners and angles of the forms and around all reinforcement and embedded items without permitting the material to segregate. Concrete shall be deposited as close as possible to its final position in the forms, and in so depositing, there shall be no vertical drop greater than 5 feet except where suitable equipment is provided to prevent segregation and where specifically authorized. Depositing of the concrete shall be so regulated that it will be effectively placed and consolidated in horizontal layers not exceeding 5 feet in thickness with a

minimum of lateral movement. The amount of concrete deposited shall be such that it can be readily and thoroughly consolidated and shall not exceed 4 cubic yards in one pile. All concrete-placing equipment and methods shall be subject to approval. Concrete placement will not be permitted when, in the opinion of the Contracting Officer, weather conditions prevent proper placement and consolidation.

Drop chutes, elephant trunks, and/or tremies should be used in walls and columns to prevent free-fall of the concrete and to allow the concrete to be placed through reinforcing steel. They should be moved at short intervals to prevent stacking of concrete. Vibrators should be used to move the mass of concrete through the forms.

3.3.2.1 Time Interval Between Mixing and Placing

Concrete mixed in stationary mixers and transported by nonagitating equipment shall be placed within 30 minutes after it has been mixed, unless otherwise authorized. When concrete is truck mixed or when a truck mixer or agitator is used for transporting concrete mixed by stationary mixers, the concrete shall be delivered to the site of the work, and discharge shall be completed within 1-1/2 hours after introduction of the cement to either the water or aggregate.

3.3.2.2 Hot-Weather Placing

The temperature of the concrete when deposited in the forms during hot weather shall not exceed 85 degrees F except as further required by paragraph: TRANSPORTING AND PLACING and Special Temperature Controlled Concrete. An approved retarding admixture may be used in accordance with paragraph: MATERIAL SPECIFICATION to facilitate placing and finishing. Steel forms and reinforcement and conveying and placing equipment shall be cooled if necessary to assist in maintaining specified concrete-placing temperature. The temperature of the fresh concrete shall be measured in accordance with ASTM C 1064.

3.3.2.3 Cold Weather Placing

The temperature of the concrete when deposited in the forms shall not be less than 40 degrees F. The ambient temperature of the placement area and all surfaces to receive concrete shall be above 32 degrees F. Materials entering the mixer shall be free from ice, snow, and frozen lumps. The heating of mixing water or aggregates necessary to keep the concrete temperature above 40 degrees F shall be closely regulated so that the concrete temperature does not exceed 60 degrees F. An accelerator may be used when approved in advance.

3.3.2.4 Special Temperature-Controlled Concrete

Special temperature control is applicable to mass concrete and concrete placements in the elements indicated in the table below. Mass concrete placements are placements having a horizontal thickness greater than 36 inches. Regardless of the requirements specified above, the concrete shall have a temperature not exceeding that specified below and not less than 40 degrees F, when measured at least 20 minutes after mixing. Heating of the mixing water or aggregates will not be permitted until the temperature of the concrete has decreased to 45 degrees F. The materials shall be heated in such a manner that they will be free from ice, snow, and frozen lumps before entering the mixer.

Structural Element	Maximum Placing Temperature (Degrees F) Low Heat Mixtures	High Heat Mixtures
Intake Structure Below Elevation 470 (Sta 9+10 to Sta 10+00)	70	55
Intake Structure Above Elev 570 and Below Elevation 500 (Sta 9+10 to Sta 10+00)	75	60
Stillng Basin Invert Between Sta 18+13.40 and Sta Sta 21+02.50	70	55

The following methods may be used for cooling plastic concrete:

(1) Precooling of aggregates by screening from direct sunlight, spraying with chilled water, and (if required) sending the aggregates through a chilling system just prior to batching.

(2) Using chilled water for mixing or substituting up to 50 percent by weight of ice for mixing water.

(3) Liquid nitrogen cooling of the concrete mixture by (a) injection of liquid nitrogen into the mixer after completion of batching and mixing, and (b) mixing liquid nitrogen with parts of the aggregate prior to batching and mixing.

3.3.2.5 Concrete Lifts

The depth of concrete placed in each lift will be as shown in the drawings. All concrete shall be deposited in approximately horizontal layers about 1-1/2 feet in thickness in stepped progression at such a rate that the formation of cold joints will be prevented. Slabs shall be placed in one lift, unless 2-1/2 foot or more deep. Where 7-1/2 foot or greater lift depths are permitted, the Contractor shall furnish approved cantilever forms that are jointed or hinged approximately midheight to facilitate placement against surfaces sloping more than 10 degrees from vertical. At the beginning of the placing of a lift, the top half of a hinged or jointed form shall be retracted to such a position that it does not interfere with the operation of buckets placing concrete adjacent to the form. A minimum of five successive horizontal layers in stepped progression shall be used for 7-1/2 foot lifts. Where 5 foot lifts are required, a minimum of three successive horizontal layers in stepped progression shall be used. Each new layer of concrete shall be placed on the oldest exposed layer. The maximum exposed bulkhead face of concrete between adjacent monoliths shall not exceed 40 feet except as otherwise approved.

3.3.2.6 Consolidation

Immediately after placing, each layer of concrete shall be consolidated by internal vibrating equipment. Vibrators shall not be used to cause concrete to flow for significant distances within the forms. Hand spading may be used if necessary together with internal vibration along formed surfaces permanently exposed to view. Form vibrators shall not be used. The vibrator shall be inserted vertically at uniform spacing over the

entire area of placement. The distance between insertions shall be approximately 1-1/2 times the radius of action of the vibrator. The vibrator shall penetrate rapidly to the bottom of the layer and at least 6 inches into the preceding unhardened layer if such exists. It shall be held stationary until the concrete is consolidated and then withdrawn slowly. Slabs 8 inches or less in depth shall be consolidated by approved methods.

3.4 FINISHING

3.4.1 Finish Requirements

3.4.1.1 High Velocity Finish

A high velocity (HV) finish shall be required on all concrete surfaces exposed to high velocity floor (40 fps) from Station 9+40 to Station 20+84.50.

3.4.1.2 Permanent View Finish

A permanent view (PV) finish shall be required for all surfaces that do not require HV finish or do not have backfill placed against them as shown.

3.4.2 Unformed Surfaces

3.4.2.1 General

The ambient temperature of spaces adjacent to surfaces being finished shall be not less than 40 degrees F. In hot weather when the rate of evaporation of surface moisture, as determined by use of Figure 2.1.5 of ACI 305R, may reasonably be expected to exceed 0.2 pounds per square foot per hour, provisions for windbreaks, shading, fog spraying, or evaporation retarding film shall be made in advance of placement to prevent plastic shrinkage cracks, and such protective measures shall be taken before, during, and immediately after finishing as operations require. All unformed surfaces of concrete that are not to be covered by additional concrete or backfill shall have a float finish, unless a trowel finish is specified, and shall be true to elevation as shown on the drawings. Surfaces to receive additional concrete or backfill shall be brought to the elevation shown and left true and regular. Exterior surfaces shall be sloped for drainage unless otherwise shown in the drawing or directed. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. The concrete shall be thoroughly consolidated before finishing operations commence or before leaving it for future concrete or backfill placement.

3.4.2.2 Float Finish

Surfaces to receive a float finish shall be screeded and darbied or bullfloated to bring the surface to the required finish level with no coarse aggregate visible. No water, cement, or mortar shall be added to the surface during the finishing operation. Floating may be performed by use of suitable hand floats or power-driven equipment. Hand floats shall be of aluminum or magnesium. After the water sheen has disappeared, the concrete, while still green but sufficiently hardened to bear a man's weight without deep imprint, shall be floated to a true even plane.

3.4.2.3 Trowel Finish

A hard steel trowel shall be applied to all unformed surfaces requiring HV finish. Concrete surfaces shall first be given a float finish. After surface moisture has disappeared, the surface shall be troweled to a smooth, even, dense finish, free from blemishes, including trowel marks. In lieu of hand finishing, an approved power finishing machine may be used in accordance with the directions of the machine manufacturer. A final hard steel troweling shall be done by hand. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. Surfaces or edges likely to be injured during the construction period shall be protected from damage.

3.4.2.4 Broom Finish

A broom finish shall be applied as indicated on the drawings. The concrete surface to be broom finished shall first be given a float finish. The surface shall then be broomed with a stiff fiber-bristle broom in a direction transverse to that of the traffic.

3.4.2.5 Bridge Decks

The Contractor shall set elevation control points, to be approved by the Contracting officer, which shall be used to establish the grade and cross section of the concrete deck surface. A tight wood float finish shall be provided on the surface of the bridge deck where excessive surface working will not be permitted. The exposed concrete surfaces shall be broomed in a transverse direction with a fine textured hair push broom to produce a uniform surface texture and eliminate float marks or shall be finished using an alternative method approved by the Contracting Officer achieving a similar surface texture. Brooming, shall be done when the surface is sufficiently set to prevent deep scaring. If directed by the Contracting Officer, a fine spray of water shall be applied to the surface immediately in advance of brooming.

3.4.3 Formed Surface Repair

3.4.3.1 General

Within 4 hours after removal of forms all ridges or lips shall be removed and undesirable local bulging on the surfaces to be permanently exposed shall be remedied. Concrete formwork requirements for the classes of finish specified are covered in SECTION: FORMWORK FOR CONCRETE. Epoxy bonding agent shall be in accordances with ACI 503.2. Latex bonding agent meeting the requirements of ASTM C 1059 may be used instead of epoxy resin if concrete to be patched was placed less than 24 hours previously.

3.4.3.2 High Velocity (HV) Finish

All defective areas (imperfections, voids, honeycomb, rock pockets, bug holes negative surface irregulatories, etc...) shall be repaired as shown below:

SIZE	REMOVAL	PATCHING
1/4 to 1 inch in diameter (and holes left by removal of form tie rods)	Reamed or chipped to a roughened surface	Epoxy bonding agent dry packed mortar

SIZE	REMOVAL	PATCHING
1 inch diameter to 16 square inches	Reamed, chipped or cut to a minimum depth of 3 inches	Epoxy bonding agent dry packed mortar or concrete
Areas exceeding 16 square inches	Dove-tailed saw cuts to a depth of 3 inches in a rectangular pattern and chipped 1 inch past reinforcement or 6 inches total	Epoxy bonding agent concrete (saw cuts that extend past corners shall be patched with dry-packed mortar)

NOTES: Grinding to meet tolerance is acceptable only if in accordance with paragraph: Surface Requirements

Patch tolerances are smaller and are critical for HV patch and nearby concrete stability. The finished patch shall be flush at the edges and it's surface shall not vary by more that 1/16 inch or it shall be removed and redone.

3.4.3.3 Permanent View (PV) Finish

The surfaces of specified exterior formed concrete permanently exposed to view shall meet the following requirements: defective areas, voids, honeycomb, and bug holes which exceed 1/2-inch in diameter and holes left by removal of form tie rods shall be reamed or chipped and filled with dry pack mortar. Defective and unsound concrete areas larger than 36 square inches and deeper than 2 inches shall be outlined by saw cuts at least 1 inch deep in an approved rectangular pattern, the defective concrete removed, and repaired with concrete replacement as specified in paragraph: Material and Procedure for Repairs. The prepared area shall be brush-coated with an approved epoxy resin or with a neat cement grout after dampening and then filled with mortar or concrete.

3.4.3.4 All Other Formed Surfaces

After removal of forms, areas of honeycomb or voids which exceed 4 inches in diameter shall be reamed or chipped and filled with dry pack mortar. Defective and unsound areas larger than 48 square inches and deeper than 2 inches shall be removed by saw cuts in a rectangular pattern and repaired with concrete replacement as specified in paragraph: Material and Procedure for Repairs. The prepared area shall be brush-coated with an approved epoxy resin or with a neat cement grout after dampening and then filled with mortar or concrete.

3.4.3.5 Material and Procedure for Repairs

The cement used in the dry-pack mortar or replacement concrete shall be a blend of the cement utilized for production of project concrete and white portland cement properly proportioned so that the final color of the mortar or concrete will match adjacent concrete. Trial batches shall be utilized to determine the proportions required to match colors. Dry-pack mortar shall consist of 1 part cement to 2-1/2 parts fine aggregate. The fine aggregate shall be that utilized for production of project concrete. The

mortar shall be remixed without addition of water until it obtains the stiffest consistency that will permit placing. Mortar shall be thoroughly compacted into the prepared void by tamping, rodding, ramming, etc., and struck off to adjacent concrete. Replacement concrete shall be produced utilizing project materials to meet requirements of the concrete it is replacing, and shall be proportioned by the Contractor and approved by the Contracting Officer. It shall be drier than the usual mixtures and shall be thoroughly compacted into the prepared void by tamping, rodding, ramming, etc., and shall be struck off and finished to adjacent concrete. Forms shall be utilized as required or as directed. Metal tools shall not be used to finish permanent view (PV) surfaces. The repaired areas shall be cured for 7 days. The temperature of the in-situ concrete, adjacent air and replacement mortar or concrete shall be above 50 degrees F during placement, finishing, and curing. Packaged materials meeting the requirements of ASTM C 928 may be used in lieu of dry-pack mortar when approved.

3.4.4 Toilet Room Finish

Tilework shall be laid out to minimize cuts less than one half the tile in size. Wall and floor tiles shall be aligned to give straight uniform grout lines. Tiles shall be set in portland cement mortar, and grout manufacturer's recommendations shall be followed as to grouting procedures and precautions.

3.5 CURING AND PROTECTION

3.5.1 Curing Time

All concrete shall be cured by one of the following methods or combination of methods for the period of time given below corresponding to the cementing materials used in the concrete:

Type III portland cement	3 days
Type II portland cement	14 days
Portland cement blended with 25 percent or less fly-ash or GGBF slag	14 days
Portland cement blended with more than 25 percent fly-ash or GGBF slag	21 days

Curing shall begin immediately after placing. The Contractor shall have all equipment needed for adequate curing and protection of the concrete on hand and ready to install before actual concrete placement begins. The curing medium and method, or the combination of media and methods used, shall be as approved in accordance with paragraph: SUBMITTALS, SD-08 Statements, submittal item "Curing".

3.5.2 Moist Curing

Horizontal and nearly horizontal surfaces shall be moist cured by ponding, by covering with a minimum uniform thickness of 2 inches of continuously saturated sand, or by covering with saturated nonstaining burlap or cotton mats. Burlap and cotton mats shall be rinsed to remove soluble substances before using. Other surfaces shall be moist cured when approved or directed. Concrete that is moist cured shall be maintained continuously, not periodically, wet for the duration of the entire curing period. Water for curing shall comply with the requirements of the paragraph: WATER. If

the water, sand, mats, etc. cause staining or discoloration of permanently exposed concrete surfaces, the surfaces shall be cleaned by a method approved. When wood forms are left in place during curing, the forms shall be kept continuously wet except for sealed insulation curing in cold weather. When steel forms are left in place on vertical surfaces during curing, the forms shall be carefully broken loose from the hardened concrete and curing water continuously introduced into the void. Horizontal construction joints shall be allowed to dry sufficiently to remove free water immediately prior to placing the next lift.

3.5.3 Membrane Curing

3.5.3.1 Materials

Membrane curing may be used on surfaces that are not specified or directed to receive moist curing and that are not to receive a grout-cleaned finish. Membrane-forming curing compound shall not be used on surfaces that contain protruding steel reinforcing, that are heated by free steam, that will have additional concrete bonded to them, or that are to be grout-cleaned. Compound conforming to ASTM C 309, Type 2, Class A, may be used on surfaces that will not be exposed to view when the project is completed. Only pigmented compound of the styrene acrylate or chlorinated rubber formulation conforming to ASTM C 309, Class B, requirements may be used on surfaces that are to be painted or to receive bituminous roofing or water proofing or floors that are to receive adhesive applications of resilient flooring. The curing compound selected by the Contractor for such use shall be compatible with any subsequent paint, roofing, coating, or flooring specified elsewhere in the contract.

3.5.3.2 Application

The curing compound shall be applied to formed surfaces immediately after the forms are removed. The surfaces shall be thoroughly moistened with water, and the curing compound applied as soon as free water disappears. The curing compound shall be applied to unformed surfaces as soon as free water has disappeared provided steps have been taken when necessary to prevent premature loss of free water due to excessive evaporation as described in paragraph: UNFORMED SURFACES. The curing compound shall be applied in a two-coat continuous operation by motorized power-spraying equipment or pressure-tank equipment operating at a minimum pressure of 75 psi with provisions for continuous agitation. The application equipment shall be approved in advance. Hand-operated pressure applicators ("garden sprayers") shall not be used except in small, isolated areas as approved. The compound shall be applied at a uniform coverage of not more than 400 square feet per gallon for each coat. The second coat shall be applied perpendicular to the first coat. Concrete surfaces that have been subjected to rainfall within 3 hours after the curing compound has been applied shall be resprayed by the method and at the coverage specified. All concrete surfaces on which the curing compound has been applied shall be adequately protected for the duration of the entire curing period from pedestrian and vehicular traffic and from any other influence that will disrupt the continuity of the curing membrane.

3.5.4 Sheet Curing

Sheets shall be used only on horizontal or near horizontal surfaces. The sheets shall comply with the requirements of ASTM C 171, except that polyethylene sheet shall not be used. All surfaces shall be thoroughly wetted and completely covered with waterproof paper, or polyethylene-coated

burlap. Covering shall be laid with light-colored side up. Covering shall be lapped not less than 4 inches and taped to form a continuous cover with completely closed joints. The sheet shall be weighted to prevent displacement so that it remains in contact with the concrete during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.

3.5.5 Curing Color-Conditioned Concrete

In order to achieve color uniformity proper curing materials as recommended by the color additive manufacturer shall be used.

3.5.6 Protection

No fire or excessive heat shall be permitted near or in direct contact with concrete at any time. No vibratory earth compaction equipment or pile-driving equipment shall be operated within 100 feet horizontally of concrete less than 5 days old. Blasting shall not be permitted within 100 feet horizontally of concrete less than 90 days old. Blasting plans shall be approved by the Contracting Officer. All galleries, conduits, and other openings through the concrete shall be kept closed or sealed during the entire construction period. The surface of the concrete shall be protected from rain or snow during placing.

3.6 BASE PLATES AND BEARING PLATES

3.6.1 Setting of Plates

After being plumbed and properly positioned, column base plates, bearing plates for beams and similar structural members, and machinery and equipment base plates shall be provided full bearing using Nonshrink grout. The space between the top of the concrete bearing surface and the bottom of the plate shall not be less than 1/24 of the width of the plate or 1/2 inch, whichever is greater. Concrete surfaces shall be clean, free of oil, grease, and laitance, and shall be damp. Metal surfaces shall be clean and free of oil, grease, and rust.

3.6.2 Nonshrink Grout

Nonshrink grout shall conform to the requirement of paragraph: MATERIAL SPECIFICATION. Water content shall be the minimum that will provide a flowable mixture and completely fill the space to be grouted without segregation, bleeding, or reduction of strength.

3.6.2.1 Mixing and Placing

Mixing and placing shall be in conformance with the material manufacturer's instructions and as specified. Ingredients shall be thoroughly dry-mixed before adding water. After adding water, the batch shall be mixed for 3 minutes. Batches shall be sized to allow continuous placement of freshly mixed grout. Grout not used within 30 minutes after mixing shall be discarded. The space between the top of the concrete or masonry bearing surface and the plate shall be filled with the grout. Forms shall be of wood or other suitable material for retaining the grout and shall be removed after the grout has hardened. If Grade "A" grout is used, all surfaces, including top surfaces, shall be formed to provide restraint. The placed grout shall be worked to eliminate voids; however, overworking and breakdown of the initial set shall be avoided. Grout shall not be

retempered or subjected to vibration from any source. Where clearances are unusually small, placement shall be made under pressure with a grout pump. Temperature of the grout, and of surfaces receiving the grout, shall be maintained at 65 to 85 degrees F until after setting.

3.6.2.2 Treatment of Exposed Surfaces

Those types of grout containing metallic aggregate, Grade B or C grout, shall, after setting, have exposed surfaces under cut back 1 inch from the edge of the base plate and immediately covered with a thick coat of mortar proportioned by weight of one part portland cement, two parts sand, and sufficient water to make the mixture placeable. The parge coat shall have a smooth, dense finish. The exposed surface of other types of nonshrink grout shall have a smooth, dense finish.

3.6.2.3 Curing

Grout and parge coats shall be cured in conformance with paragraph: CURING AND PROTECTION.

3.7 BLOCK-OUT CONCRETE

3.7.1 Composition and Proportions

Block-out concrete shall be composed of portland cement, water, fine and coarse aggregate, and admixtures. The concrete mixture proportions, including admixture, will be provided by the Contracting Officer. An expansive admixture shall be used to cause the blockout concrete to expand to fit snugly in the space that confines it. The expansive admixture shall conform to the requirements of ASTM C 937 for grout fluidifier. Any block-out concrete not placed within 30 minutes after contact of the cement and admixture shall be wasted. The block-out shall be confined on all sides to provide restraint.

3.7.2 Placing Block-out Concrete

Blockouts shall be provided as shown on the plans for the embedment of gate seal seats, gate guides, bulkhead guides, beams embedded for bulkhead seals, crane rails, and other embedded metalwork as appropriate. Prior to installation of embedded items, the block-outs or recesses shall be cleaned in accordance with applicable requirements of the paragraph on construction joint treatment. After installation of embedded items and prior to placing any forms, all surfaces of the block-outs or recesses and surfaces of items to be embedded shall be thoroughly cleaned of all loose material, oil, grease, and other contaminants which might reduce the bond between the surfaces of the blockouts or recesses and new concrete. Extreme caution shall be exercised in placing block-out concrete to avoid distortion or displacement of the embedded items.

3.8 TESTS AND INSPECTIONS

3.8.1 General

The Contractor shall perform the following inspection and tests as described, and, based upon the results of these inspections and tests, he shall take the action required and submit reports as required. When, in the opinion of the Contracting Officer, the concreting operation is out of control, concrete placement shall cease. The laboratory performing the tests shall be on-site and shall conform with the requirements given in

ASTM C 1077. The individuals who sample and test concrete or the constituents of concrete as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I. The Government will inspect the laboratory, equipment, and test procedures prior to start of concreting operations and at least once per year thereafter for conformance with ASTM C 1077. The individual who performs the inspection shall have demonstrated a knowledge and ability equivalent to the ACI minimum guidelines for certification of Concrete Construction Inspector, Level II.

3.8.2 Testing and Inspection Requirements

3.8.2.1 Fine Aggregate

a. Grading - At least once during each shift when the concrete plant is operating, there shall be one sieve analysis and fineness modulus determination in accordance with ASTM C 136 , ASTM C 117 and COE CRD-C 104 for the fine aggregate or for each fine aggregate if it is batched in more than one size or classification. The location at which samples are taken may be selected by the Contractor as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits. The results shall be recorded on a sheet on which are also shown the specification limits applicable to the project.

b. Fineness Modulus Control Chart - Results for fineness modulus shall be grouped in sets of three consecutive tests, and the average and range of each group shall be plotted on a control chart. The upper and lower control limits for average shall be drawn 0.10 units above and below the target fineness modulus, and the upper control limit for range shall be 0.20 units above the target fineness modulus.

c. Corrective Action for Fine Aggregate Grading - When the amount passing any sieve is outside the specification limits, the fine aggregate shall be immediately resampled and retested. If there is another failure for any sieve, the fact shall immediately be reported. Whenever a point on the fineness modulus control chart, either for average or range, is beyond one of the control limits, the frequency of testing shall be doubled. If two consecutive points are beyond the control limits, the process shall be considered out of control and concreting shall be stopped. Notify the Contracting Officer, and take immediate steps to rectify the situation. After two consecutive points have fallen within the control limits, testing at the normal frequency may be resumed.

d. Moisture Content Testing - When in the opinion of the Contracting Officer the electric moisture meter is not operating satisfactorily, there shall be at least four tests for moisture content in accordance with ASTM C 566 during each 8-hour period of mixing plant operation. The times for the tests shall be selected randomly within the 8-hour period. An additional test shall be made whenever the slump is shown to be out of control or excessive variation in workability is reported by the placing foreman. When an electric moisture meter is operating satisfactorily, at least two direct measurements of moisture content shall be made per week to check the calibration of the meter. The results of tests for

moisture content shall be used to adjust the added water in the control of the batch plant.

e. Moisture Content Corrective Action - Whenever the moisture content of the fine aggregate changes by 0.5 percent or more, the scale settings for the fine-aggregate batcher and water batcher shall be adjusted (directly or by means of a moisture compensation device).

3.8.2.2 Coarse Aggregate

a. Grading - At least once during each shift in which the concrete plant is operating, there shall be a sieve analysis in accordance with ASTM C 136 for each size of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. However, the Contractor shall be responsible for delivering the aggregate to the mixer within specification limits. A test record of samples of aggregate taken at the same locations shall show the results of the current test as well as the average results of the five most recent tests including the current test. The Contractor may adopt limits for control coarser than the specification limits for samples taken other than as delivered to the mixer to allow for degradation during handling. When facilities are available to test samples five times as large as those required in ASTM C 136, no averaging shall be done.

b. Corrective Action for Grading - When the amount passing any sieve is outside the specification limits, the coarse aggregate shall be immediately resampled and retested. If the second sample fails on any sieve, that fact shall be reported. Where two consecutive averages of five tests (or two consecutive tests where large samples are used) are outside specification limits, the operation shall be considered out of control, and that fact shall be reported, concreting shall be stopped, and immediate steps shall be taken to correct the grading.

c. Coarse Aggregate Moisture Content - A test for moisture content of each size group of coarse aggregate shall be made at least once a shift. When two consecutive readings for smallest size coarse aggregate differ by more than 1.0 percent, frequency of testing shall be increased to that specified previously for fine aggregate.

d. Coarse Aggregate Moisture Corrective Action - Whenever the moisture content of any size of coarse aggregate changes by 0.5 percent or more, the scale setting for the coarse aggregate batcher and the water batcher shall be adjusted to compensate for this.

e. Particle Shape Testing - When directed, a problem exists in connection with aggregate particle shape, tests shall be made in accordance with ASTM D 4791. Testing frequency shall be not less than one per day, when directed.

f. Particle Shape Corrective Action - When testing for particle shape is required, two consecutive failures in the same sieve size shall be immediately reported, who shall determine what corrective action is needed.

g. Material Finer than the No. 200 Sieve - When in the opinion of the

Contracting Officer, a problem exists in connection with the cleanliness of aggregate, tests shall be made in accordance with ASTM C 117. Testing frequency shall be as directed.

h. Corrective Action for Material Finer than the No. 200 Sieve - When material finer than the No. 200 sieve exceeds 1.0 percent of the weight of the aggregate finer than 1-1/2 inches or 0.5 percent of the weight of the aggregate coarser than 1-1/2 inches, the Contracting Officer shall be notified and steps, such as washing or other corrective action, shall be initiated immediately.

3.8.2.3 Quality of Aggregates

a. Frequency of Quality Tests - Prior to submitting samples for mixture proportioning studies and 30 days prior to the start of concrete placement, the Contractor shall perform the tests for aggregate quality in the following list. In addition, after the start of concrete placement, the Contractor shall perform tests for aggregate quality in accordance with the following frequency schedule. Samples tested after the start of concrete placement shall be taken immediately prior to entering the concrete mixer.

PROPERTY	FREQUENCY FINE AGGREGATE	FREQUENCY COARSE AGGREGATE	TEST
Specific Gravity	Every 3 months	Every 3 months	ASTM C 127 ASTM C 128
Absorption	Every 3 months	Every 3 months	ASTM C 127 ASTM C 128
Clay Lumps and Friable Particles	Every 3 months	Every 3 months	ASTM C 142
Material Finer than the No. 200 Sieve	Every 3 months	Every 3 months	ASTM C 117
Organic Impurities	Annually	Not applicable	ASTM C 40
L.A. Abrasion	Not applicable	Every 6 months	ASTM C 131 ASTM C 535

b. Corrective Action for Aggregate Quality - If the result of a quality test fails to meet the requirements for quality during submittal of samples for mixture-proportioning studies or immediately prior to start of concrete placement, production procedures or materials shall be changed and additional tests shall be performed until the material meets the quality requirements prior to proceeding with either mixture-proportioning studies or starting concrete placement. After concrete placement commences, whenever the result of a test for quality fails the requirements, the test shall be rerun immediately. If the second test fails the quality requirement, the fact shall be reported and immediate steps taken to rectify the situation.

3.8.2.4 Scales

a. Weighing Accuracy - The accuracy of the scales shall be checked by test weights at least once a month for conformance with the applicable requirements of paragraph: EQUIPMENT. Such tests shall also be made as directed whenever there are variations in properties of the fresh concrete that could result from batching errors.

b. Batching and Recording Accuracy - Once a week the accuracy of each batching and recording device shall be checked during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. The Contractor shall confirm that the calibration devices described in paragraph: EQUIPMENT for checking the accuracy of dispensed admixtures, are operating properly.

c. Scales Corrective Action - When either the weighing accuracy or batching accuracy does not comply with specification requirements, the plant shall not be operated until necessary adjustments or repairs have been made. Discrepancies in recording accuracies shall be corrected immediately.

3.8.2.5 Batch-Plant Control

The measurement of all constituent materials including cementitious materials, each size of aggregate, water, and admixtures shall be continuously controlled. The aggregate weights and amount of added water shall be adjusted as necessary to compensate for free moisture in the aggregates. The amount of air-entraining agent shall be adjusted to control air content within specified limits. A report shall be prepared indicating type and source of cement used, type and source of pozzolan or slag used, amount and source of admixtures used, aggregate source, the required aggregate and water weights per cubic yard, amount of water as free moisture in each size of aggregate, and the batch aggregate and water weights per cubic yard for each class of concrete batched during plant operation.

3.8.2.6 Concrete

a. Slump Testing - At least two slump tests shall be made in accordance with ASTM C 143 on each concrete mixture produced during each 8-hour period or less of concrete production each day. Additional tests shall be made when excessive variation in workability is reported. The result of each test for each mixture shall be plotted on a control chart on which the upper and lower limits are set as specified in paragraph: MIXTURE PROPORTIONING. The range shall be plotted on a control chart on which the upper control limit is 2 inches. Samples for slump shall be taken at the mixer, however the Contractor is responsible for delivering the concrete to the placement site at the stipulated slump. If the Contractor's materials or transportation methods cause slump loss between the mixer and the placement, samples shall be taken at the placement site as often as required by the Contracting Officer.

b. Slump Corrective Action - Whenever points on the control chart approach the upper or lower control limits, an adjustment shall be made in the batch weights of water and fine aggregate. The adjustments are to be made so that the total water content does

not exceed that amount specified in the mixture proportions provided based on the free water available with the aggregates and that amount of water batched. If the adjustments to the batch weights of water and aggregates do not satisfactorily produce the required slump, the Contracting Officer may adjust the mixture proportions if the fine-aggregate moisture content is stable and within the required limits. When a single slump is outside the control limits, such adjustment is mandatory. As soon as practical after each adjustment, another test shall be made to verify the correctness of the adjustment. Whenever two consecutive individual slump tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range above the upper control limits, the slump shall be considered to be out of control, the concreting operation halted, and the additional testing for aggregate moisture content required shall be undertaken, and action taken immediately to correct the problem.

c. Air Content - At least two tests for air content shall be made on randomly selected batches of each concrete mixture produced during each 8 hour period of concrete production. Additional tests shall be made when excessive variation in workability is reported. Tests shall be made in accordance with ASTM C 231. The average of each set of two tests for each mixture shall be plotted on control charts on which the average percent and upper and lower limits are set in accordance with paragraph MIXTURE PROPORTIONING for each NMSA. The range between two consecutive tests for each mixture shall be plotted on a control chart on which the upper control limit is 3.0 percent. Samples for air content shall normally be taken at the mixer, however the Contractor is responsible for delivering the concrete to the forms at the proper air content. Samples shall be taken at the placement site as often as required, depending on the Contractors delivery method, to determine any air loss.

d. Air Content Corrective Action - Whenever points on the control chart approach the upper or lower control limits, an adjustment should be made in the amount of air-entraining admixture batched. If a single test result is outside the specification limit, immediate adjustment is mandatory. As soon as practical after each adjustment, another test shall be made to verify the correction of the adjustment. Whenever a point falls above the upper control for range, the dispenser shall be calibrated to ensure that it is operating correctly and with good reproducibility. Whenever two consecutive points either for average or range are outside the control limits, the Contracting Officer shall be notified.

3.8.2.7 Inspection Before Placing

Foundation or construction joints, forms, and embedded items shall be inspected by the Contractor in sufficient time prior to each concrete placement in order to certify that they are ready to receive concrete. The results of each inspection shall be reported in writing.

3.8.2.8 Concrete Placement

a. Placing Inspection - The placing foreman shall supervise all

placing operations, shall determine that the correct quality of concrete or grout is placed in each location as directed, and shall be responsible for measuring and recording concrete temperatures and ambient temperature hourly during placing operations, weather conditions, time of placement, yardage placed, and method of placement.

b. Placing Corrective Action - The placing foreman shall not permit placing to begin until he has verified that an adequate number of vibrators in working order and with competent operators are available. Placing shall not be continued if any pile of concrete is inadequately consolidated. If any batch of concrete fails to meet the temperature requirements, immediate steps shall be taken to improve temperature controls.

3.8.2.9 Vibrators

a. Vibrator Testing and Use - The frequency and amplitude of each vibrator shall be determined in accordance with COE CRD-C 521 prior to initial use and at least once a month when concrete is being placed. Additional tests shall be made as directed when a vibrator does not appear to be adequately consolidating the concrete. The frequency shall be determined while the vibrator is operating in concrete with the tachometer being held against the upper end of the vibrator head while almost submerged and just before the vibrator is withdrawn from the concrete. The amplitude shall be determined with the head vibrating in air. Two measurements shall be taken, one near the tip and another near the upper end of the vibrator head, and these results averaged. The make, model, type, and size of the vibrator and frequency and amplitude results shall be reported in writing.

b. Vibrator Corrective Action - Any vibrator not meeting the requirements of paragraph: PREPARATION FOR PLACING shall be immediately removed from service and repaired or replaced.

3.8.2.10 Curing

a. Moist Curing Inspections - At least twice each shift, and twice per day on nonwork days an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded.

b. Moist Curing Corrective Action - When a daily inspection report lists an area of inadequate moistness, immediate corrective action shall be taken, and the required curing period for those areas shall be extended by one (1) day.

c. Membrane Curing Inspection - No curing compound shall be applied until the Contractor's authorized representative has verified that the compound is properly mixed and ready for spraying. At the end of each operation, he shall estimate the quantity of compound used by measurement of the container and the area of concrete surface covered and compute the rate of coverage in square feet per gallon. He shall note whether or not coverage is uniform.

d. Membrane Curing Corrective Action - When the coverage rate of the curing compound is less than that specified or when the coverage is not uniform, the entire surface shall be sprayed again.

e. Sheet Curing Inspection - At least once each shift and once per day on nonwork days, an inspection shall be made of all areas being cured using sheets. The condition of the covering and the tightness of the laps and tapes shall be noted and recorded.

f. Sheet Curing Corrective Action - When a daily inspection report lists any tears, holes, or laps or joints that are not completely closed, the tears and holes shall promptly be repaired or the sheets replaced, the joints closed, and the required curing period for those areas shall be extended by one (1) day.

3.8.2.11 Cold Weather Protection and Sealed Insulation Curing

At least once each shift and once per day on nonwork days an inspection shall be made of all areas subject to cold weather protection. The protection system shall be inspected for holes, tears, unsealed joints, or other incongruities which could result in damage to the concrete. Special attention shall be taken at edges, corners, and thin sections. Any deficiencies shall be noted, corrected, and reported.

3.8.2.12 Cold Weather Protection Corrective Action

When a daily inspection report lists any holes, tears, unsealed joints, or other incongruities, the deficiency shall be corrected immediately and the period of protection extended for one (1) day.

3.8.2.13 Mixer Uniformity

Prior to the start of concrete placing and once every 3 months when concrete is being placed, or once for every 75,000 cubic yards of concrete placed, whichever results in the longest time, interval uniformity of concrete mixing shall be determined in accordance with paragraph: EQUIPMENT. The initial and every fourth set of tests shall be regular tests performed on three batches of concrete. Intermediate uniformity tests shall be abbreviated tests performed on a single batch of concrete. If the mixer fails the abbreviated test, a regular test shall be immediately performed. Whenever adjustments in a mixer or increased mixing time are required because of failure of a uniformity test, the mixer shall be reevaluated by a regular test after the adjustments have been completed. If the Contractor proposes to reduce a mixing time, a regular test shall be performed to evaluate the proposed time. Additional testing shall be performed when directed when there is visible evidence of possible improper mixer performance. Results of all uniformity tests shall be reported in writing.

3.8.2.14 Mixer Uniformity Corrective Action

When a mixer fails to meet mixer uniformity requirements, either the mixing time shall be increased, batching sequence changed, batch size reduced, or adjustments shall be made to the mixer until compliance is achieved.

3.8.3 Reports

All results of tests or inspections conducted shall be reported informally as they are completed and in writing daily. A weekly report shall be prepared for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold weather protection, reports of pertinent temperatures shall

be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all contractor quality control records.

-- End of Section --

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DIVISION 03 - CONCRETE

SECTION 03310

ROOF DECKING, CAST-IN-PLACE LIGHT WEIGHT CONCRETE

-- End of Section Table of Contents --

SECTION 03310

ROOF DECKING, CAST-IN-PLACE LIGHT WEIGHT CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 211.2	(1998) Standard Practice for Selecting Proportions for Structural Lightweight Concrete

AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI-01	(1986; Addenda 1989) Cold-Formed Steel Design Manual

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 185	(1997) Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
ASTM A 446	(1993) Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality
ASTM A 525	(1993) General Requirement for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM C 150	(1997) Portland Cement
ASTM C 260	(1995) Air-Entraining Admixtures for Concrete
ASTM C 330	(1989) Lightweight Aggregates for Structural Concrete
ASTM C 567	(1991) Unit Weight of Structural Lightweight Concrete

AMERICAN WELDING SOCIETY (AWS)

AWS A2.4	(1998) Standard Symbols for Welding, Brazing and Nondestructive Examination

1.2 DESIGN REQUIREMENTS

1.2.1 Concrete

Light weight concrete shall be proportioned for a maximum air-dry unit weight of 110 pcf as verified by type made in accordance with ASTM C 567.

1.2.2 Roof Decking

Design of steel deck shall conform to AISI-01. Units shall be designed for attachment to the structural supports by welding as indicated on the plans.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Roof Decking; G.

Drawings indicating shop and erection details for form systems proposed to be used. Drawings shall show cuts, vent holes, cut-outs for other trades, connections, and welds. Welds shall be indicated in accordance with AWS A2.4.

SD-06 Test Reports

Field-Control Tests

Submit copies of field control tests.

SD-07 Certificates

Mixing and proportioning; G.

Certified copies of mix design report for light weight concrete indicating mixture proportions, average compressive strength in psi, and wet unit weight at point of placement for the type proposed for the project. Allowances shall be made for any unit weight changes resulting from handling and placing methods.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Admixtures

Air-entraining admixtures shall conform to ASTM C 260. Admixtures containing chloride ions shall not be used.

2.1.2 Aggregate

Light weight aggregate shall be free of asbestos and shall conform to ASTM C 330.

2.1.3 Cementitious Material

Portland cement shall conform to ASTM C 150, Type II or V, low alkali.

2.1.4 Wire Reinforcement

Reinforcement shall consist of welded wire fabric. Welded wire fabric shall conform to ASTM A 185, galvanized, 12 gauge longitudinal wires spaced on 4 inch maximum centers with 14 gauge transverse wires spaced on 8 inch maximum centers.

2.1.5 Roof Decking

Roof deck shall be galvanized steel conforming to ASTM A 446, Grade A, with coating Class G 60 conforming to ASTM A 525.

2.2 MIXING PROCEDURE

Concrete ingredients shall be mechanically mixed to produce light weight concrete of uniform consistency and a wet unit weight at point of placement required to obtain minimum compressive strength of 3000 psi. Mixing and proportioning shall be in accordance with ACI 211.2.

PART 3 EXECUTION

3.1 ROOF DECKING

Forms shall be attached to structural members by plug welding or special clips furnished by the manufacturer. Welding or the use of clips shall be in conformance with recommendations of the manufacturer. Sheets shall be placed with edge-corrugation lips pointing upward and shall be lapped not less than one full corrugation. End laps shall be located over permanent supports and shall be a minimum of 2 inches. Venting shall be as recommended by the manufacturer. Prior to placing low density concrete, areas of coating that have been damaged by welding or other operations shall have welding flux, spatter, and slag removed, shall be cleaned of loose rust and other foreign matter by wire brushing, and then coated with zinc-rich paint.

3.2 WIRE REINFORCEMENT

Wire reinforcement shall be unrolled and placed so that the long dimension is perpendicular with the flutes in the steel forms. Location of reinforcement shall be approximately in the center of the slab over the flutes.

3.3 LIGHT WEIGHT CONCRETE CONVEYING AND PLACEMENT

Conveying of light weight concrete from the mixer to place of deposit shall be by methods that will prevent segregation and loss of material. Equipment for conveying concrete shall be of such size and design to ensure uniform, continuous placement of concrete. Light weight concrete shall be deposited and screeded in a continuous operation until the placing of a panel or section is completed. Rodding, tamping, vibrating, or steel trowelling shall not be used. Runways must be planked if using buggies. Heavy concentrated loads of concrete or crews and uniform loads exceeding 20 psf must be investigated for shoring consideration. Construction loads must not exceed carrying capacity of deck.

3.4 COLD WEATHER PLACEMENT

Reinforcement, forms, fillers, and other materials that will come in contact with the light weight mixture shall be free of frost, snow, or ice.

Light weight concrete shall not be placed at temperatures below 40 degrees F or when temperatures are predicted to fall below 40 degrees F during placement, unless such placement is approved.

3.5 CURING

Curing operations shall commence at initial set of threquirmentconcrete. After curing, surfaces shall be allowed to dry sufficiently to permit subsequent application of roofing system.

3.6 FIELD-CONTROL TESTS

Field-control tests shall be performed by an approved commercial testing laboratory and shall consist of wet-density at time of placement and conformance to 3000 psi minimum compressive strength requirement.

3.7 CLEANING AND PROTECTION

Upon completion of the roof deck, the roof surfaces shall be swept clean of debris and left ready to receive the roofing. The finished deck shall be protected from damage by weather and construction operations prior to installation of roofing.

-- End of Section --

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DIVISION 03 - CONCRETE

SECTION 03371

SHOTCRETE

-- End of Section Table of Contents --

SECTION 03371

SHOTCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 506.3R	(1991) Certification of Shotcrete Nozzlemen

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 33	(1997) Concrete Aggregates
ASTM C 42	(1994) Obtaining and Testing Drilled Cores and Sawed Beam of Concrete
ASTM C 94	(1998c) Ready-Mixed Concrete
ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 150	(1997) Portland Cement
ASTM C 171	(1992) Sheet Materials for Curing Concrete
ASTM C 266	(1989) Time of Setting of Hydraulic-Cement Paste by Gillmore Needles
ASTM C 309	(1995) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 566	(1989) Total Moisture Content of Aggregate by Drying
ASTM C 618	(1997) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C 685	(1994) Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 881	(1990) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 989	(1997) Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM C 1077	(1998) Laboratories Testing Concrete and

	Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1140	(1989) Preparing and Testing Specimens from Shotcrete Test Panels
ASTM C 1141	(1994) Admixtures for Shotcrete

CORPS OF ENGINEERS (COE)

COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-06 Test Reports

Mixture Proportions; G

The recommended mixture proportions, sources of materials, and all test results shall be submitted for approval.

Aggregates

Supplier's test reports for aggregates showing the materials meet the requirements of this specification.

Accelerator Compatibility; G

The Contractor shall establish the compatibility of the job cement and the proposed accelerators.

Preconstruction Test Panels

Cores and sawed concrete beams shall be taken from test panels and tested.

SD-07 Certificates

Portland Cement

Portland cement shall be certified for compliance with all specification requirements.

Pozzolans

Fly ash and other pozzolans shall be certified for compliance with all specification requirements.

Accelerating Admixtures

Accelerating admixtures shall be certified for compliance with

all specification requirements.

Curing Materials

Curing materials shall be certified for compliance with all specification requirements.

Qualifications; G

Qualifications of each nozzleman shall be certified.

1.3 QUALITY ASSURANCE

The Contractor shall provide facilities and labor as may be necessary for obtaining and testing representative test samples. Shotcrete shall be sampled and tested by the method given in paragraph: STRENGTH TESTING.

1.4 MIXTURE PROPORTIONS

If test data from experience are not available or accepted, specimens shall be made and tested from mixtures having three or more different proportions. The recommended mixture proportions, sources of materials, and all test results shall be submitted for acceptance. Mixture proportions for shotcrete shall be selected on the basis of compressive strength tests of cores obtained from test panels fabricated in accordance with ASTM C 1140 and having minimum dimensions of 30 by 30 by 4 inches. Cores shall be continuously moist cured until testing at 28 days age. For mixture acceptance purposes, the average compressive strength of at least three cores shall be at least equal to 1.2 times the required compressive strength specified in paragraph: EVALUATION AND ACCEPTANCE.

1.5 EVALUATION AND ACCEPTANCE

Final acceptance of the shotcrete will be based on compressive strength results obtained from cores . The required compressive strength of cores shall not be less than 4000 psi at 28 days age when tested in accordance with ASTM C 42. The average compressive strength of cores taken from the test panel, representing a shift or not more than 50 cubic yardsof shotcrete tested at 28 days of age, shall equal or exceed the required compressive strength specified with no individual core less than 85 percent of the required compressive strength. When the length of a core is less than 1.94 times the diameter, the correction factors given in ASTM C 42 will be applied to obtain the compressive strength of individual cores.

1.6 QUALIFICATIONS

The Contractor shall submit a resume for each nozzleman certifying that each has not less than 1 year's experience for the particular type of shotcrete to be applied. The resume shall include company name, address, and telephone number, name of supervisor, and detailed description of work performed. All nozzlemen shall be certified in accordance with ACI 506.3R. Qualifications of additional nozzlemen throughout the job shall be similarly submitted for approval.

1.7 PRECONSTRUCTION TEST PANELS

Specimens of the preconstruction test panels shall be made by each application crew using the equipment, materials, mixture proportions, and procedures for each mixture being considered, and for each shooting

position to be encountered in the job. The same reinforcement as in the structure shall be provided in at least one-half of the panel to test for proper embedment of reinforcing steel. The test panels shall be fabricated to the same thickness as the structure, but not less than 4 inches. At least five 3-inch diameter cores from each panel shall be taken for testing for compressive strength in accordance with ASTM C 1140 .

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

Cementitious materials shall be portland cement in combination with pozzolan or ground granulated blast-furnace slag (GGBFS) and shall conform to appropriate specifications listed below.

2.1.1.1 Portland Cement

Portland cement shall meet the requirements of ASTM C 150 Type IIlow alkali.

2.1.1.2 Pozzolan

Pozzolans shall conform to ASTM C 618, Class F, with the loss on ignition limited to 6 percent.

2.1.1.3 Ground Granulated Blast-Furnace Slag

Ground granulated blast-furnace slag shall conform to ASTM C 989, Grade 120.

2.1.2 Aggregates

Aggregates shall conform to ASTM C 33 with the combined grading of coarse and fine aggregates conforming to the grading shown below.

SIEVE SIZE	PERCENT BY MASS PASSING INDIVIDUAL SIEVES
3/8 in.	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

* Fine and coarse aggregates shall be batched separately to avoid segregation.

2.1.3 Water

Fresh, clean, potable mixing water or nonpotable water which meets the requirements of COE CRD-C 400 shall be used.

2.1.4 Admixtures

2.1.4.1 Accelerators

When accelerating admixtures complying with ASTM C 1141, Type II, Grade 1, are to be used, the Contractor shall establish the accelerator compatibility of the job cement and the proposed accelerators using ASTM C 266, except as modified herein. The powdered accelerator shall be blended with 50 grams of cement until uniform and 15 milliliters of water shall then be added. The liquid accelerator shall first be mixed with 15 milliliters of water and then added to 50 grams of cement. Three percent of the proposed accelerator by mass of cement shall be used as a starting point. Mixing shall be accomplished within 15 seconds. The specimen shall be molded within 1 minute of adding the mixing water. If initial set is 2 minutes or less and a final set is 10 minutes or less, the accelerator is considered compatible. If these values are not achieved in the first test, additional tests shall be run using 2 percent and 4 percent of accelerator.

2.1.5 Curing Materials

Curing materials shall meet the following requirements.

2.1.5.1 Impervious Sheet Materials

ASTM C 171, type optional except polyethylene film, if used, shall be white opaque.

2.1.5.2 Membrane-Forming Curing Compound

ASTM C 309, Type 1-D or Type 2.

PART 3 EXECUTION

3.1 PRODUCTION OF SHOTCRETE

The shotcrete shall be produced by wet-mix process .

3.1.1 Wet Mix Process

3.1.1.1 Batching and Mixing

Batching and mixing shall be accomplished in accordance with the applicable provisions of ASTM C 94. If volumetric batching and mixing are used, the materials shall be batched and mixed in accordance with the applicable provisions of ASTM C 685. The mixing equipment shall be capable of thoroughly mixing the specified materials in sufficient quantity to maintain continuous placing. Ready-mix shotcrete complying with ASTM C 94 may be used.

3.1.1.2 Delivery Equipment

The equipment shall be capable of delivering the premixed materials accurately, uniformly, and continuously through the delivery hose. Recommendations of the equipment manufacturer shall be followed on the type and size of nozzle to be used and on cleaning, inspection, and maintenance of the equipment.

3.1.2 Air Supply

The Contractor shall provide a supply of clean, dry air adequate for maintaining sufficient nozzle velocity for all parts of the work and, if required, for simultaneous operation of a suitable blowpipe for clearing away rebound.

3.2 PREPARATION OF SURFACES

3.2.1 Earth

Earth shall be compacted and trimmed to line and graded before placement of shotcrete. Surfaces to receive shotcrete shall be dampened.

3.2.2 Existing Concrete

All unsound and loose materials shall be removed by sandblasting, grinding, or high-pressure water jets before applying shotcrete. Any area to be repaired shall be chipped off or scarified to remove offsets which would cause an abrupt change in thickness without suitable reinforcement. Edges shall be tapered to leave no square shoulders at the perimeter of a cavity. The surface shall be dampened but without visible free water.

3.2.3 Rock

Rock surfaces shall be cleaned to remove loose or drummy material, mud, running water, and other foreign matter that will prevent bond of the shotcrete. The rock surface shall be dampened prior to placement of shotcrete.

3.2.4 Shotcrete

When a layer of shotcrete is to be covered by a succeeding layer at a later time, it shall first be allowed to develop its initial set. Then all laitance, loose material, and rebound shall be removed by brooming or scraping. Hardened laitance set shall be removed by sandblasting and the surface thoroughly cleaned.

3.2.5 Construction Joints

Unless otherwise specified, construction joints shall be tapered to a shallow edge form, about 1 inch thick. If nontapered joints are specified, special care shall be taken to avoid or remove trapped rebound at the joint. The entire joint shall be thoroughly cleaned and wetted prior to the application of additional shotcrete.

3.3 PLACEMENT OF SHOTCRETE

3.3.1 General

Shotcrete shall be placed using suitable delivery equipment and procedures. The area to which shotcrete is to be applied shall be clean and free of rebound or overspray.

3.3.2 Placement Techniques

3.3.2.1 Placement Control

Thickness, method of support, air pressure, and water content of shotcrete shall be controlled to preclude sagging or sloughing off. Shotcreting shall be discontinued or suitable means shall be provided to screen the nozzle stream if wind or air currents cause separation of the nozzle stream during placement.

3.3.2.2 Corners

Horizontal and vertical corners and any area where rebound cannot escape or be blown free shall be filled first.

3.3.3 Placement Around Reinforcement

The nozzle shall be held at such distance and angle to place material behind reinforcement before any material is allowed to accumulate on the face of the reinforcement. Shotcrete shall not be placed through more than one layer of reinforcing steel rods or mesh in one application unless demonstrated by preconstruction tests that steel is properly encased.

3.3.4 Cover of Reinforcement

The following minimum cover shall be provided, unless otherwise indicated on the drawings.

a. For shotcrete used as linings, coatings, slab, or wall: 3/4 inch.

b. For required structural reinforcement in beams, girders, and columns: 1-1/2 inches.

3.3.5 Placement Precautions

The following precautions shall be taken during placement.

a. Placement shall be stopped if drying or stiffening of the mixture takes place at any time prior to delivery to the nozzle.

b. Rebound or previously expended material shall not be used in the shotcrete mixture.

3.4 REPAIR OF DEFECTS

3.4.1 Defects

Defective areas larger than 48 square inches or 2 inches deep shall be removed and replaced with fresh shotcrete. These defects include honeycombing, lamination, dry patches, voids, or sand pockets. Defective areas shall be removed in accordance with the procedures described in paragraph: EXISTING CONCRETE and replaced with fresh shotcrete.

3.4.1.1 Repairs

All repairs shall be made within 1 week of the time the deficiency is discovered. All unacceptable materials shall be removed and repaired by the procedures described in the following two paragraphs. Voids and holes left by the removal of tie rods in all permanently exposed surfaces not to be backfilled and in surfaces to be exposed to water shall be reamed and completely filled with dry-patching mortar as specified below.

3.4.1.2 Minor Patching

Minor patching may be accomplished with a dry-pack mixture, or with materials as approved by the Contracting Officer. Patches that exceed 0.1 cubic foot in volume shall receive a brush coat of approved epoxy resin meeting ASTM C 881, Type II, as a prime coat. Care shall be taken not to spill epoxy or overcoat the repair surface so that the epoxy runs or is squeezed out onto the surface which will remain exposed to view. Epoxy

resin shall be used in strict conformance with manufacturer's recommendations with special attention paid to pot life, safety, and thin film tack time.

3.5 CURING AND PROTECTION

3.5.1 Initial Curing

Immediately after finishing, shotcrete shall be kept continuously moist for at least 3 days. One of the following materials or methods shall be used:

a. Ponding or continuous sprinkling.

b. Absorptive mat or fabric, sand, or other covering kept continuously wet.

c. Curing Compounds. On natural gun or flash finishes, use the coverage application requirement of 100 square feet per gallon or twice the manufacturer's requirement, whichever is less. Curing compounds shall not be used on any surfaces against which additional shotcrete or other cementitious finishing materials are to be bonded unless positive measures, such as sandblasting, are taken to completely remove curing compounds prior to the application of such additional materials.

3.5.2 Final Curing

Additional curing shall be provided immediately following the initial curing and before the shotcrete has dried. One of the following materials or methods shall be used:

a. Continue the method used in initial curing.

b. Application of impervious sheet material conforming to ASTM C 171.

3.5.3 Formed Surface

If forms are to be removed during curing period, one of the curing materials or methods listed in paragraph: INITIAL CURING shall be used immediately. Such curing shall be continued for the remainder of the curing period.

3.5.4 Duration of Curing

Curing shall be continued for the first 7 days after shotcreting or until the specified compressive strength of the in-place shotcrete as determined by specimens obtained and tested in accordance with ASTM C 42 is achieved.

3.5.5 Temperature Considerations

The air temperature in contact with the shotcrete shall be continuously maintained at a temperature above 40 degrees F for at least 3 days after placement. No shotcrete shall be applied when the concrete surface or air in contact with the concrete surface is below 40 degrees F.

3.6 TESTS

3.6.1 Strength Testing

Test specimens shall be initially cured onsite, then shall be transported in an approved manner to an approved testing laboratory meeting the

requirements of ASTM C 1077 within 48 hours of scheduled testing time.

3.6.1.1 Test Panel

One test panel shall be made for every 50 cubic yards of shotcrete placed but not less than one per each shift during which any shotcrete is placed. Panels shall have minimum dimensions of 18 by 18 by 4 inches and shall be gunned in the same positions as the work represented during the course of the work by the Contractor's regular nozzleman. Panels shall be field cured in the same manner as in the job. Three inch diameter cores shall be drilled from each panel at least 40 hours prior to testing and tested in accordance with ASTM C 1140. If the quality of shotcrete is questionable, the Government may saw or core the panel specimens to determine the shotcrete quality and if remedial action is necessary.

3.6.1.2 Compressive Strength

The compressive strength of the shotcrete shall be determined from the average of three cores obtained from a test panel representing a specific volume of shotcrete and tested on the 28th day after placement in the structure.

3.6.2 Aggregate Moisture

Prior to batching the shotcrete and at least once during a shift in which shotcrete is being batched, the coarse and fine aggregate moisture content shall be determined in accordance with ASTM C 566. The batch weights of both the aggregates and mixing water shall be appropriately adjusted to account for the available free moisture in the aggregates. The amount of free moisture in the aggregates, expressed as pounds of water per cubic yard, shall be recorded on the batching ticket and delivered to the Contracting Officer prior to placement during the shift. The Contracting Officer will have the option to request additional aggregate moisture content tests for each of the required tests.

3.6.3 Grading

The grading of the coarse and fine aggregate shall be determined in accordance with ASTM C 136. The fine and coarse aggregate grading shall be determined prior to batching the shotcrete and at least once during a shift in which shotcrete is being batched. The Contracting Officer will have the option to require one additional sieve analysis test for aggregate type.

3.6.4 Thickness

The minimum shotcrete thickness shall be as shown in the drawings. The unhardened shotcrete shall be checked for thickness using a probe by the nozzleman or laborer at the time of placement. These thickness checks shall be at 15-minute intervals and all low or thin areas shall be corrected by applying additional shotcrete.

3.6.5 Mixture Proportions

Record and check mixture proportions at least once per shift for weigh batching. Record and check mixture proportions as recommended by ASTM C 685 at least once per shift for volumetric batching and continuous mixing plants.

3.6.6 Preparations

Prior to each placement of shotcrete, the Contractor's inspector shall certify in writing or by an approved checkout form that cleanup and preparations are in accordance with the plans and specifications.

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DIVISION 03 - CONCRETE

SECTION 03415

PRECAST-PRESTRESSED CONCRETE

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SECTION 03415

PRECAST-PRESTRESSED CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO-01	Standard Specifications for Highway Bridges

ACI INTERNATIONAL (ACI)

ACI 211.1	(1991) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 214	(1977; R 1989) Recommended Practice for Evaluation of Strength Test Results of Concrete
ACI 318/318R	(1995) Building Code Requirements for Structural Concrete and Commentary

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31/C 31M	(1998) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(1997) Concrete Aggregates
ASTM C 39	(1996) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 150	(1997) Portland Cement
ASTM C 172	(1997) Sampling Freshly Mixed Concrete
ASTM C 231	(1997) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(1995) Air-Entraining Admixtures for Concrete
ASTM C 494	(1998) Chemical Admixtures for Concrete
ASTM C 618	(1997) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral

Admixture in Portland Cement Concrete

PRECAST PRESTRESSED CONCRETE INSTITUTE (PCI)

PCI Mnl-116s	(1985) Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products
PCI Mnl-120	(1992) PCI Design Handbook - Precast and Prestressed Concrete

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Erection; G

The Contractor shall prepare and submit for approval complete shop drawings that show the precast unit manufacturer's recommended details and materials for the work required by paragraphs DELIVERY, STORAGE, AND HANDLING and ERECTION. The shop drawings shall include: design computations; marking of the units for the placing drawings; anchorages for work of other trades; anchorages to support construction; size and location of steel tendons; methods of stressing; location and sizes of all openings 12 in. wide or larger to be cast into members; formwork; joints between units and other construction; reinforcing steel details; method of curing; and, pickup points and lifting devices.

SD-03 Product Data

Erection Plan; G

The Contractor shall prepare a detailed erection plan which shall be submitted at least 15 days prior to the date that erection of members is to begin.

Design Calculations

Design calculations shall be submitted prior to the initiation of manufacture of members to be used under this contract.

Concrete Mixture Proportions; G

Concrete mixture proportions shall be submitted for approval.

Construction Records

Construction records of the manufacturing, handling, and erection of the precast prestressed concrete members shall be submitted.

SD-06 Test Reports

Materials

Certified test reports of required material tests shall be submitted prior to the use of the materials in the work. Reports shall be furnished for each shipment and shall be identified with specific lots.

Concrete

The results of concrete strength testing by the contractor shall be submitted not more than 5 days after the tests are completed.

SD-07 Certificates

Cement
Pozzolan
Air-Entraining Admixture
Water-Reducing Admixture
Accelerating Admixture
Aggregates

Cement, Pozzolan, Air-Entraining Admixture, Water-Reducing Admixture, Accelerating Admixture, and Aggregates shall be certified for compliance with all specifications requirements.

Air Content

Each precast member delivered to the jobsite shall be accompanied by a certificate certifying that the air content in the concrete in that member is in compliance with the specifications. The certification must be based on an air content test conducted in conformance with ASTM C 231 on at least one of the batches of concrete from which the member was cast.

1.3 SYSTEM DESCRIPTION

1.3.1 Design Requirements

1.3.1.1 Precast-Prestressed Members and Connections

Design of members and connections shall be in accordance with ACI 318/318R and PCI Mnl-120.

1.3.1.2 Loads

Loadings for members and connections shall include all dead load, live load, applicable lateral loads such as wind and earthquake, applicable construction loads such as handling, erection loads, and other applicable loads.

1.3.1.3 Design Calculations

Design calculations for members and connections not shown in the contract drawings shall be made by a registered professional engineer experienced in the design of precast-prestressed concrete.

1.3.2 Performance Requirements

Perform the following testing to ensure the materials and method used meet the requirements of these specifications and will produce precast-prestressed concrete members which are suitable for their intended use.

1.3.2.1 High-Strength Steel Tendons

Testing shall be as specified in Section 03230 STEEL STRESSING TENDONS AND ACCESSORIES FOR PRESTRESSED CONCRETE.

1.3.2.2 Concrete

Concrete shall be sampled and cylinders made in accordance with ASTM C 172 and ASTM C 31/C 31M.

a. Concrete Test Cylinders. A minimum of two concrete test cylinders per bed shall be made to verify the strength of concrete at the time of stress transfer and a minimum of two test cylinders per day or 50 cubic yards of concrete or fraction thereof, whichever results in the most cylinders, shall be made for each mix design to verify the attainment of the specified strength.

b. Cylinder Making. Cylinders shall be made as near as possible to the location where they will be cured and shall not be disturbed in any way from 1/2 hour after casting until they are either 24 hours old or ready to be tested. Concrete in cylinders may be consolidated by rodding or by vibration as specified in ASTM C 31/C 31M.

c. Cylinder Curing

(1) Test cylinders shall be cured with similar methods as the members they represent. In lieu of actual curing with the members, cylinders may be cured in curing chambers correlated in temperature and humidity with the beds. In such a case, the correlation shall be constantly verified by use of recording thermometers in the curing chambers and comparison with the temperature records of beds and by use of the same methods of moisture retention for curing chambers and casting beds.

(2) For beds cured by steam or radiant heat, cylinders shall be placed at random points along the bed. If there is any indication of variable heat, cylinders shall be placed in the coolest area.

(3) Test cylinders to indicate compliance with specified 28-day or earlier strength shall remain in the bed with the member until the member is removed. At that time, the cylinders shall be removed from their molds and placed in storage in a moist condition at 73.4 degrees plus or minus 3 degrees F.

d. Testing of Cylinders

(1) Testing of cylinders to determine compressive strength shall be performed in accordance with ASTM C 39. The strength of concrete at any given age shall be determined as the average of two cylinders, except a single cylinder test can be used to determine stress transfer strength or predictive strengths at less than 28 days.

(2) Testing machines shall be calibrated in accordance with ASTM C 39.

1.3.2.3 Air Content

The air content tests shall be conducted in accordance with ASTM C 231. At least one air content test shall be conducted on the concrete from which each member is cast.

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Transportation

1.4.1.1 Transporting Members

In transporting members by truck, railroad car, or barge, provision shall be made for supporting the members as described above, except battens can be continuous over more than one stack of units, with adequate bracing to ensure their maintaining the vertical position and damping of dangerous vibrations. Trucks with double bolsters are satisfactory provided the members are fully seated on the outer bolsters at not more than 3 feet or the depth of the member from the end and the inner bolster is not more than 8 feet from the end of the member or the designated pickup point. Adequate padding material shall be provided between tie chains or cables to preclude chipping of concrete.

1.4.1.2 Lateral Deflection or Vibration

Any noticeable indication of lateral deflection or vibration during transportation shall be corrected by rigid bracing between members or by means of lateral trussing.

1.4.2 Storage

1.4.2.1 Storage Areas

Storage areas for prestressed members shall be stabilized, and suitable foundations shall be provided, so differential settlement or twisting of members will not occur.

1.4.2.2 Stacked members

Stacked members shall be separated and supported by battens placed across the full width of each bearing point. Battens shall be arranged in vertical planes at a distance not greater than the depth of the member from designated pickup points. Battens shall not be continuous over more than one stack of precast units. Stacking of members shall be such that lifting devices will be accessible and undamaged. The upper members of a stacked tier shall not be used as storage areas for shorter members or equipment.

1.4.3 Handling of Members

The location of pickup points for handling of the members and details of the pickup devices shall be shown in shop drawings. Members shall be handled only by means of approved devices at designated locations. Members shall be maintained in an upright position at all times and picked up and supported as shown in approved shop drawings.

PART 2 PRODUCTS

2.1 MATERIALS

Materials shall comply with the following:

2.1.1 Cement

Portland cement shall conform to ASTM C 150, Type II or V, low alkali.

2.1.2 Pozzolan

Pozzolan shall conform to ASTM C 618 Class F with the loss of ignition limited to 6 percent.

2.1.3 Other Materials

2.1.3.1 Aggregates

Aggregates shall meet the requirements of ASTM C 33.

2.1.3.2 Admixtures

In no event shall admixtures containing chlorides or nitrates be used in the concrete.

a. Air-entraining admixture shall be certified to comply with ASTM C 260.

b. Water-reducing admixture shall be certified to comply with ASTM C 494 Type A.

c. Accelerating admixture shall be certified to comply with ASTM C 494 Type C.

2.1.4 Steel Reinforcement

Steel reinforcement shall be in accordance with Section 03200 CONCRETE REINFORCEMENT

2.1.5 Steel Tendons

Steel tendons shall be in accordance with Section 03230 STEEL STRESSING TENDONS AND ACCESSORIES FOR PRESTRESSED CONCRETE.

2.1.6 Bearing Pads

Bearing pads shall conform to AASHTO-01.

2.1.7 Embedded Items

Embedded items shall conform to the applicable parts of Section 05120 STRUCTURAL STEEL AND MISCELLANEOUS METALWORK.

2.2 CONCRETE MIXTURE PROPORTIONS

2.2.1 Concrete

Concrete shall be composed of cementitious material, water, fine and coarse aggregate, and admixtures. The cementitious material shall be portland cement or portland cement in combination with pozzolan. The admixtures shall be an air-entraining agent and may include a water-reducing admixture when its formulation and use are approved.

2.2.2 Proportions

The concrete mixture proportions shall meet the following requirements:

Maximum Water-cement ratio (w/c) = 0.50.
Specified Strength = 4000 psi at 28 days.

Air Content = 5 to 7 percent as determined in accordance with ASTM C 231. Proportions shall be selected so that the maximum permitted w/c ratio is not exceeded and so as to produce an average strength exceeding the design strength f'c by the amount indicated below. Where the production facility has a standard deviation record determined in accordance with ACI 214, based on 30 consecutive strength tests of similar mixture proportions to that proposed, obtained within 1 year of the time when concrete placing is expected, it shall be used in selecting average strength. The average strength used as the basis for selecting proportions shall exceed the specified strength f'c by at least.

400 psi if standard deviation is less than 300 psi
550 psi if standard deviation is 300 to 400 psi
700 psi if standard deviation is 400 to 500 psi
900 psi if standard deviation is 500 to 600 psi

If the standard deviation exceeds 600 psi or if a standard deviation record is not available, proportions shall be selected to produce an average strength at least 1,200 psi greater than the specified strength.

Mixtures shall be proportioned in accordance with ACI 211.1. The trial mixtures shall be formulated using the same materials as those to be used in the units supplied under this specification, and the selected proportions shall be submitted for approval with the results of cylinder strengths at 28 days.

2.3 EVALUATION AND ACCEPTANCE

2.3.1 Concrete

A test result shall be the average of the strengths of the two test cylinders made in accordance with paragraph: SYSTEM DESCRIPTION, subparagraph: PERFORMANCE REQUIREMENTS, subparagraph: CONCRETE, subparagraph "a", CONCRETE TEST CYLINDERS. The strength level of the concrete will be considered satisfactory if the average of all sets of three consecutive strength tests equal or exceed the specified strength f'(c) and no individual test falls below the specified value by more than 500 psi. Members manufactured with concrete that does not meet the strength requirements shall be rejected.

2.3.1.1 Air Content

All members cast with concrete having a measured air content less than 5 percent shall be rejected. Members cast with concrete having an air content up to 9 percent may be incorporated into the work if the strength requirements are met.

2.3.2 Tolerances

The precast-prestressed members shall be manufactured within the following tolerances. Members failing to meet the dimensional tolerances shall be rejected.

2.3.2.1 Length of Member

The length of the member shall not deviate from the length shown in the contract drawings by more than plus or minus 3/4 inch or plus or minus1/8 inch per 10 feet of length, whichever is greater.

2.3.2.2 Cross-sectional Dimensions

The cross-sectional dimensions of a member, if less than 36 inches, shall not vary by more than plus or minus 1/4 inch and, if over 36 inches, they shall not vary by more than plus or minus 3/8 inch.

2.3.2.3 Camber

The actual camber of members shall not deviate from the computed camber by more than plus or minus 1/8 inch per 10 feet but not more than plus or minus 1/2 inch maximum total deviation.

2.3.2.4 Position of Tendons

The position of the tendons shall not deviate from the design position by more than plus or minus 1/4 inch.

2.3.2.5 Handling Devices

The actual position of handling devices shall not deviate from the designed position by more than plus or minus 6 inches.

2.3.2.6 Anchors and Inserts

The actual position of anchors and inserts shall not vary by more than plus or minus 1 inch from positions shown in the contract drawings.

2.3.2.7 Slab Thickness

The thickness of slab shall not vary from the dimensions in the drawings by more than plus 1/4 inch or minus 1/8 inch.

2.3.2.8 Depth of Member at Support

At the supports, the depth of a member shall not deviate from the dimensions shown in the contract drawings by more than plus or minus 1/4 inch.

2.3.2.9 Squareness of Ends

The ends of members shall not deviate from being square by more than plus or minus 1/4 inch. Squareness shall be checked in both the vertical and horizontal planes.

2.3.3 Defects

2.3.3.1 Minor Defects

Minor defects are those which involve less than 36 square inches of

concrete and do not expose stressing tendons or reinforcing steel. These defects will be repaired as specified hereinafter. Cracks which are visible but are 0.01 inch wide or less will be accepted.

2.3.3.2 Major Defects

Major defects are those which involve more than 36 square inches of concrete or expose stressing tendons or reinforcing steel. If one or more major defects appear in a member, it shall be rejected. Cracks of a width of more than 0.01 inch shall be cause for rejection of the member.

PART 3 EXECUTION

3.1 FABRICATION

Fabrication of precast-prestressed members shall follow the applicable provisions of the PCI Mnl-116s, except as specified herein.

3.2 BEDS AND FORMS

3.2.1 Casting Beds

All casting beds shall have concrete support on unyielding foundations.

3.2.2 Forms

Forms, both fixed and movable, shall be of steel. All forms and beds shall be thoroughly cleaned after each use.

3.2.3 Bulkheads

Bulkheads, spacers, templates, and similar equipment having influence on the accuracy of dimensions and alignment shall be regularly inspected and maintained after each casting.

3.2.4 Alignment

Accurate alignment of forms shall be maintained during the casting operation to assure compliances with tolerances specified in paragraph: EVALUATION AND ACCEPTANCE. Leakage of the paste in form joints is not acceptable, and measures shall be taken to prevent such leakage. Measures shall also be taken to provide corner chamfers.

3.2.5 Form Ties

For exposed members, form ties, if used, shall be of the threaded or snap-off type so no parts will be left at the surface of the finished concrete.

3.3 TENDONS

The tendons shall be placed, stressed, and destressed in accordance with Section 03230 STEEL STRESSING TENDONS AND ACCESSORIES FOR PRESTRESSED CONCRETE.

3.4 STEEL REINFORCEMENT

Steel bars and welded wire fabric shall be placed in accordance with Section 03200 CONCRETE REINFORCEMENT.

3.5 CONCRETE PLACEMENT

Concrete placement shall be in accordance with Section 03305 CONCRETE, except that once placement is started in a member it shall be carried on in a continuous operation until the member is completed. Members shall be cast in a horizontal position and casting in tiers will not be permitted. Adequate vibration shall be provided with internal and form vibrators so the cast members shall be free of rock pockets or surface blemishes resulting from inadequate vibration. Cold joints shall not be permitted in prestressed concrete members. If delays occur that result in hardening of the concrete so it will not receive a vibrator and again become plastic, the concrete shall be removed and the forms shall be washed out and refilled, otherwise partially cast members will be rejected.

3.6 CURING AND PROTECTION

Concrete for the manufacturing of the precast-prestressed concrete members shall be cured and protected in accordance with Section 03305 CONCRETE or by other methods further specified here.

3.6.1 Curing with Steam at Atmospheric Pressure

Steam curing shall be under a suitable enclosure to retain the live steam to minimize moisture and heat losses. The enclosure shall allow free circulation of the steam around the sides and top of the beams. Steam jets shall be so positioned so they do not discharge directly on the concrete, forms, or test cylinders. The cycle of steam application shall conform to the following:

3.6.1.1 Curing After Placing and Vibrating

After placing and vibrating, the concrete shall be allowed to attain its initial set before the steam is applied. During the period between placement of the concrete and application of steam, provisions shall be made to prevent surface drying by means of a coating of membrane curing compound, moist covers, or equally effective methods. Application of the steam shall be delayed not less than 2 hours and not more than 10 hours after the time of concrete placement. If the ambient temperature is below 50 degrees F, enough heat shall be applied to maintain the concrete at its placing temperature.

3.6.1.2 Temperature Increase

The ambient temperature within the casting enclosure shall be increased at a rate not to exceed 40 degrees F per hour. Temperature increase shall be as uniform as possible.

3.6.1.3 Temperature Range

The temperature shall be increased until the ambient temperature in the casting enclosure is between 140 and 160 degrees F. Once this temperature range is reached, it shall be maintained until the concrete has reached the compressive strength necessary for stressing or destressing the tendons.

3.6.1.4 Temperature Decrease

In discontinuing the steam curing, the ambient air temperature shall decrease at a rate not to exceed 40 degrees F per hour. Temperature

decrease shall be as uniform as possible.

3.6.1.5 Recording Thermometers

Recording thermometers showing the time-temperature relationship through the curing period from placing concrete to transfer of prestress shall be provided. At least one recording thermometer per casting enclosure shall be used. The desired curing time-temperature relationship shall be placed on the recording chart of the recording thermometer to aid the personnel controlling the temperature during curing. Recording charts shall be made available upon request and shall be clearly visible during the curing process.

3.6.2 Curing with Radiant Heat and Moisture

3.6.2.1 Radiant Heat

Radiant heat may be applied to beds by means of pipe circulating steam, hot oil, or hot water or by electric blankets or heating elements on forms. Pipes, blankets, or elements shall not be in contact with concrete, form surface, or test cylinders.

3.6.2.2 Moisture Loss

During the cycle of radiant heat curing, effective means shall be provided to prevent rapid loss of moisture in any part of the member. Moisture may be applied by a covering of moist burlap or cotton matting. Moisture may be retained by covering the member with a plastic sheet in combination with an insulating cover or by applying a liquid seal coat or membrane curing compound.

3.6.2.3 Temperature Limits

Temperature limits and use of recording thermometer shall be as specified for curing with steam at atmospheric pressure.

3.6.2.4 Termination of Curing

Termination of curing shall be as specified in Section 03305 CONCRETE unless the concrete has been cured by one of the two methods stated above. Termination of curing for concrete cured by either the steam at atmospheric pressure method or the radiant heat with moisture shall be determined based on the compressive strength of the concrete necessary for stressing or destressing the tendons.

3.7 REPAIRS

All honeycombed areas, chipped corners, air pockets over 1/4 inch in diameter, and other minor defects shall be repaired. Form offsets of fins over 1/8 inch shall be ground smooth. All unsound concrete shall be removed from defective areas prior to repairing. All surfaces permanently exposed to view shall be repaired by a blend of portland cement and white cement properly proportioned so that the final color when cured will be the same as adjacent concrete.

3.8 FINISHING

3.8.1 Formed Surfaces

The top surface of the slab units shall be given a coarse texture by brooming with a stiff bristled broom or by other suitable devices which will result in uniform transverse sawing in advance of curing operations. The removal of laitence and curing compound from top surfaces will be required for concrete overlay.

3.9 ERECTION

Erection shall comply with the following.

3.9.1 Storage Provisions

All provisions for storage and handling given in paragraph: DELIVERY, STORAGE, AND HANDLING shall be observed at the erection site.

3.9.2 Seating of Precast Prestressed Concrete Members

The precast prestressed concrete members shall be set into place in a manner which assures full bearing. If the bearing called for in the contract drawing is not obtained, then the members shall be removed and the situation corrected.

Keyways shall be filled with concrete produced from aggregate with one inch maximum grading. Keyways shall be watertight before placing concrete. The concrete shall be thoroughly hydrated. No equipment or other loads shall be allowed in any span until at least 72 hours after the last concrete has been placed in the keyways. Deck shear connector rods, shown as tie rods on the plans and bolts, nuts and washers shall be of structural steel and shall be galvanized. Openings for transverse connections shall be accurately placed and shall conform to the details shown on the plans. Nuts shall be tightened to snug fit after the deck units are positioned and prior to placing mortar in the keyways. A nut shall be tightened after the washer in the keyways between two units has been in place at least twenty-four hours. Threads at the ends of bolts or rods shall be burred to prevent loosening of the nut. Where the ends of the transverse rods will be exposed, the nuts and the ends of rods shall be recessed so that all metal shall be at least 1 inch wider than surface of the member. After two nuts have been tightened, the excess shall be filled with water.

3.9.3 Welding

Welding during erection shall be done in accordance with Section 05501 METALWORK FABRICATION, MACHINE WORK AND MISCELLANEOUS PROVISIONS. When welding or burning with a welding electrode, the ground shall be attached directly to the base metal. Under no circumstances shall the member be used as a conductor for the ground.

3.9.4 Erection Plan

The erection plan shall be in sufficient detail so that adequacy of equipment, techniques, and accessories can be determined and comments offered. Acceptance of the Contractor's erection plan shall not relieve the Contractor of his responsibility for erecting precast prestressed members into position as required by the plans and specifications.

3.10 CONSTRUCTION RECORDS

Complete construction records shall be kept of the manufacturing, handling, and erection of the precast-prestressed concrete members. Records shall be

kept for, but not limited to, the following items:

a. Specifications of material used in the manufacture of the members.

b. Time-temperature history of the concrete members from casting to the transfer of the prestress force.

c. Records of the tendon stressing operation including initial prestress force, measured elongation, how it was measured, and how the tendons were stressed and destressed.

d. Records of inspection of the members before and after the prestress force is transferred to the members.

e. Records of the inspection of the members each time they are moved.

f. Records of any defects in the member and any corrective measures taken.

-- End of Section --